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Education Department Bulletin

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New York State Museum

John M. Clarke, Director

Museum Bulletin 159

THE MINERAL SPRINGS OF SARATOGA

BY

JAMES F. KEMP

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New York State Education Department
Science Division, January 20, 1912

Honorable Andrew S. Draper LL.D.
Commissioner of Education

SIR: I have the honor to transmit to you herewith a manuscript report on the *Mineral Springs of Saratoga* which has been prepared at my request by Professor James F. Kemp, expert member of this staff, and I recommend the publication of this report as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

STATE OF NEW YORK
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Approved for publication this 20th day of January 1912

A. S. Draper
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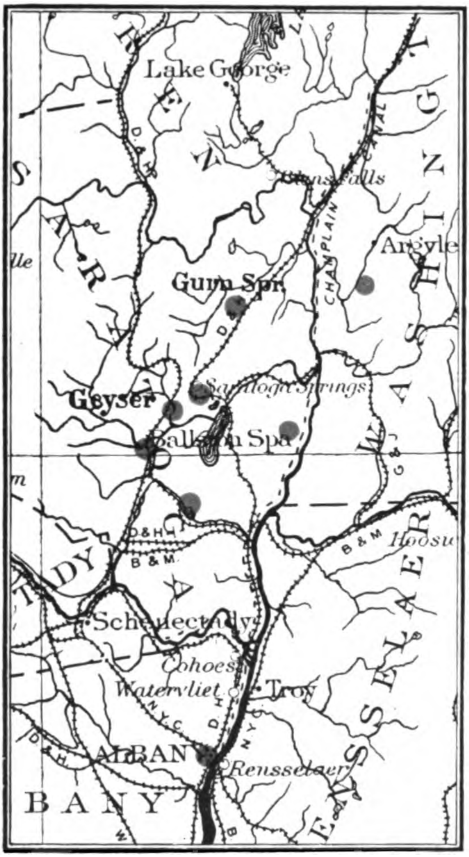

Figure 1 Outline Map of Mineral Springs Albany to Glens Falls

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New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 159

THE MINERAL SPRINGS OF SARATOGA

BY

JAMES F. KEMP

INTRODUCTION

This paper was originally written as a chapter for the bulletin upon the geology of the Saratoga Springs quadrangle which is being prepared by H. P. Cushing and R. Ruedemann. To both these geologists the writer is greatly indebted. The local geology will be set forth by them in due season. To Professor Cushing special acknowledgments should be made for the invitation, extended with the approval of the State Geologist, Doctor Clarke, to join him in the Saratoga work.

Assistance from the Hon. Edgar T. Brackett and Mr J. C. Minor, jr, in connection with books, early records, analyses and the like, has been received to a degree that has aided greatly in bringing together the necessary but widely scattered data. The writer's thanks are due to both these gentlemen.

With regard to the source of the mineral matter and gases in the springs, the writer has consulted many papers not specifically cited. Acknowledgments may be made at this point to those of A. Gautier, "Annales des Mines," 9:316, 1906; F. C. Lincoln, "Magmatic Emanations," Economic Geology, 2:258, 1907; R. T. Chamberlin "The Gases in Rocks," Carnegie Institution, 1908, and to the recent volume of A. Brun, "Recherches sur l'exhalaison volcanique," Geneva, 1911.

HISTORICAL SKETCH

The mineral springs of Saratoga first attracted the attention of the white settlers soon after the middle of the eighteenth century. In early colonial days they were westward of the first line of settlements and off the main line of such travel as there was between the valley of the Hudson and the valleys of Lake Champlain and the St Lawrence. The colonists, naturally, established themselves first in the valley of the Hudson and their earliest settlements in this region were some ten miles to the east of Saratoga Springs. The line of communication between the French villages in the valley of the St Lawrence and the Dutch and English colonists in and around Albany, whether used for peaceful or hostile purposes, also followed this main waterway. The springs were in the heart of the Mohawk hunting grounds and their salty waters undoubtedly attracted the wild animals before they caught the eye of the Indian. So far as we know, the High Rock spring was first discovered. Its mound of calcareous tufa would naturally be more conspicuous than the mere uprising of water and gas from a crevice in the rock. The High Rock was in the midst of a depressed area, at the foot of a rock escarpment and along the west side of a brook. While the smaller features are disguised by the village improvements of today, the rock bench is conspicuous, and the larger features can easily be restored in one's imagination. About a century after its discovery by the whites, a pit was sunk below the High Rock mound with the hope of cleaning the conduit and increasing the flow. It is recorded that the excavators found the mound itself resting upon two pairs of crossed logs. The logs were supported by muck and tufa, the whole forming a section of seven feet. Still lower were two feet of tufa, then one foot of muck with another log, then three feet of tufa, beneath which were charred sticks, the remains of a fire.[1] Evidence of this sort would suggest the presence of primitive man some thousands of years before the advent of the whites.

Of the identity of the first white man who viewed the High Rock spring we may not be assured. There is some reason to think that a wounded French soldier was the pioneer. But the first one whose visit attracted special attention was Sir William Johnson, the picturesque character, whose life is intimately associated with the early history of the Mohawk valley. Sir William afflicted with a bodily ailment went to the High Rock spring in 1767. His stay benefited him and he aided much in directing attention to the waters. Four years later the first cabin was built near the spring itself and then the long procession of distinguished visitors was well under way. In 1783, Generals Washington, Schuyler and Hamilton with Governor Clinton honored the primitive watering place with their presence. Four years later came Dr Samuel L. Mitchill, who was for many years the leading scientific man in New York. Accommodations improved, but in the earlier years Ballston Spa was more sought than Saratoga Springs.[1] In the early part of the nineteenth century the tide of travel again turned to Saratoga Springs and has held this course ever since.

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[1] A sketch and cross section appears in a paper by Dr Charles F. Chandler, in the American Chemist for December 1871, page 204.

As early as 1770 the medicinal properties of the waters were commented upon by Doctor Constable of Schenectady, and in 1793, in volume 2, page 1, of the Memoirs of the American Academy of Arts and Sciences, was published a letter from Dr Samuel Tenney, a regimental surgeon, at Saratoga. In the same year appeared a "Dissertation upon the Mineral Waters of Saratoga," by Dr Valentine Seaman of New York. In the course of the next century a rather extended series of papers and separate books was devoted to this subject, and it is to be hoped that with the development of the springs as a health resort of increasing prominence the curative properties of the waters and the attractions of the beautiful village and surrounding country will be more and more widely known.

The following chronological list[2] gives the dates when the older and better known springs were discovered as natural flowing vents, or were developed with the drill:

High Rock	1767	Pavilion	1839	Eureka	1868
Red Spring	1784	United States	1839	Geyser	1870
Congress	1792	Empire	1846	Crystal	1870
Columbian	1805	Excelsior	1859	Champion	1871
Hamilton	1806	Saratoga A	1865	Vichy	1872
Washington	1806	Seltzer	1865	Kissingen	1872
Putnam	1835	Union	1868	Hathorn No. 2	1890
Star	1835	Hathorn	1868	No. 3	1905

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[1] It is important to discriminate properly between Saratoga and Saratoga Springs. Saratoga is a town on the banks of the Hudson. Along its western boundary lies Saratoga Springs which is a separate town and village. Saratoga on the river was settled over fifty years before the springs attracted the attention of the whites. The battle of Saratoga was named from the eastern township, not from the springs. The fame of the springs has so far overshadowed the older settlement as to cause some confusion of mind among persons at a distance.

[2] This list is taken chiefly from a work compiled by the local newspaper, the Saratogan, and entitled, Our County and its People, page 390, 1899.

This is not a complete list of the springs. There are, for exam northeast of the village and about a mile from the High Rock, Ten springs, or Excelsior, and the Eureka White Sulphur gr Opposite Congress Park, across Broadway, is the Ainsworth. the south are the Chief, Adams and Arondack (formerly the singen) besides many drilled wells. The accompanying map gi all these locations and several others not specifically referred

In Ballston Spa, mineral springs were known toward the cl of the eighteenth century. The modern ones, however, come through drill holes which are put down through slate to the li stone at depths varying from 604 to 715 feet. There are four n active, namely, the Iron springs, not possessing much if any gas present, the Artesian Lithia, Hide's Franklin and a new one recen opened called the Washington.

In the 1835 edition of the work of Dr J. H. Steel entitl "Analysis of the Mineral Waters of Saratoga and Ballston," it stated that the Quaker springs are situated ten miles southeast Saratoga Springs and that they contain lime, magnesia, iron, and certain percentage of common salt and soda. The gaseous conten are small in comparison with those already described; their mine impregnation is not sufficient to entitle them to much attention.

These springs still exist and are feeble in their manifestations activity. A few bubbles of carbonic acid gas and of sulfurett hydrogen come through the waters.

In Mather's Report on the First District, New York State Geological Survey, 1843, page 103, there is the following record Reed's mineral spring:

> This spring is in South Argyle, Washington county, near th Moses kill. It is an acidulous carbonated water, something like th Saratoga waters, but the gas does not escape very abundantly fron the fountain. Bubbles of carbonic acid gas rise from the bottom o the fountain at short intervals, and the water has a pleasant acidulous taste, but it does not sparkle. It is resorted to by the peopl around and many ride there from Saratoga to drink the water for a change. It is a pleasant acidulous water. It is used by the people of the vicinity for raising their dough preparatory to baking it, no yeast being required. . . . The spring rises from a fissure in limestone near its junction with slate rocks, which are metamorphic, or belong to the Taconic division of rocks.

This spring must have been on the east side of the Hudson river and at least fifteen miles northeast of Saratoga Springs.

The most northerly of all the springs now important is the Gurn, eight miles from the village of Saratoga Springs. It is very actively

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flowing, well carbonated and of the same general composition as the Saratoga waters. An analysis is given later.

Still farther north in the village of Whitehall, thirty-nine miles from Saratoga Springs, is a spring called the "Adirondack," feebly carbonated and of greatly contrasted composition to the Saratoga waters in that it contains less of sodium chlorid than of either calcium or magnesium carbonate, and almost as much calcium sulphate. The total dissolved solids is only about one-eighth or one-tenth that of the Saratoga waters. (Bulletin 32, U. S. Geol. Survey, pages 27 and 32, 1886.)

To the south the mineral waters have been discovered even beyond Ballston. Thus, at Round Lake, in 1875, a drill hole was put down which reached a total depth of 1403 feet. At a point below 1300 there was struck a flow of water of composition not unlike the Saratoga waters. Its analysis is given later. The hole was torpedoed, however, and after the explosion the flow was lost.

In 1827, a well was even drilled in Albany 500 feet deep, on Ferry street, and yielded carbonated waters of the general composition of those at Saratoga Springs (L. C. Beck, Mineralogy of New York, 1841, page 138). An analysis is cited later. Albany is forty miles from Saratoga, and respectively thirty-two and twenty-six from Ballston and Round Lake. No other drilled wells have been recorded in the interval from Round Lake to Albany.

Thus waters, carbonated and of a somewhat similar composition are known over a stretch of approximately forty miles in a general north and south direction from Albany to Gurn springs, or if we include the Adirondack springs, at Whitehall, of about sixty-five miles. Between Albany and Round Lake, a distance of twenty miles, none are known. And again from the Gurn spring to Whitehall, a distance of thirty miles, none have been reported. These statements are in a measure useful in connection with general geographical conceptions, but they are not expressed in a way to be of geological significance. The springs should be grouped in northeast and southwest lines, along the known faults or fault systems. Apparently then, the Ballston-Saratoga Springs-Gurn series are to be taken on one line, with perhaps the Whitehall spring at the extreme north. The Round Lake well is five miles to the east of this line; the Quaker springs eight miles; Reed's spring in South Argyle, eight or more; and the Albany well nearly fifteen miles east of its southern prolongation.

BRIEF STATEMENT OF THE LOCAL GEOLOGY

The careful work of Professor Cushing and Doctor Ruedemann has established the following section of the strata at Saratoga Springs, from above down:

The Canajoharie shales (formerly called the Hudson River or sometimes the Utica slates). Of unknown but great thickness.	
The Amsterdam limestone (formerly called the Trenton limestone)	50′
A very important erosion interval represented in the Champlain valley by the Chazy limestone 300 feet thick, and the upper part of the Beekmantown (formerly called the Calciferous sandrock) 1200 feet. Land conditions seem to have prevailed in the Saratoga region.	
Little Falls dolomite (the lower member of the Beekmantown or Calciferous)	300′+
Hoyt limestone (formerly called the Saratoga limestone)	100′
Theresa passage beds, alternate limey and sandy layers	50′–75′
Potsdam sandstone or quartzite	200′ or less
Grenville series of ancient gneisses and metamorphic rocks with intrusive igneous masses	Indefinitely thick

Exclusive of the shales or slates at the top, which are above the productive horizon of the mineral waters, we have thus about 500 feet of limestones and dolomites, resting upon 200 feet or less of hard sandstones, and these upon the ancient metamorphosed gneisses, granites etc., which were formerly collectively described as Laurentian or Archean.

When tapped by the drill the mineral waters are chiefly obtained from the Little Falls dolomite. When the drill has penetrated the slates it strikes the waters, if such are found at all, in limestones, not far below the underside of the slates. It is possible that in some instances this may be in the Amsterdam (or old Trenton), but where the drill cores or the drillings have been identified, it is easy to recognize them as belonging to the Little Falls dolomite. The drilled wells in Saratoga Springs itself start either in the slates or in the Amsterdam (Trenton) limestone, but quickly pass through one or both of these and enter the Little Falls dolomite. In the Congress diamond drill core, which has been preserved and is available for study, the following section was disclosed:

Gravel	18′ 2″
Amsterdam limestone	16′
Little Falls dolomite	283′
Total	317′ 2″

The Hathorn drilled well penetrated to a depth of 1006 feet, of which the last few feet are reported as Potsdam. This rock is so easy to identify that there can be little question that the drill stopped in it, but the determination of the other members needs revision, and the cores are unfortunately no longer available. The depth of the well shows so much in excess of the general section as given above that there may be repetition from faulting.

The farther east wells are drilled at Saratoga Springs from the line of Spring street, the thicker the slate will be found. At Doctor Strong's sanatorium after 86 feet of gravel, nearly 300 feet of slate are reported before the limestone was met.

The drilled wells of the gas companies and the holes for mineral water at the Geysers, two miles south of Saratoga Springs, begin in the Canajoharie (Hudson River) slates. They find the waters, however, in the underlying limestones. The holes run between 300 and 400 feet deep at the General Carbonic Company's wells. The farther south one goes, the greater is the thickness of slate. Thus, at Ballston, it is 600 or 700 feet and at Round Lake between 1300 and 1400 feet.

To the north of Saratoga the Gurn spring apparently emerges from the Little Falls dolomite. The vent is some feet below the capping of gravel and is no longer visible, but the nearest outcrops are all of the dolomite.

Of the geological history of the district from the close of the time marked by the formation of the slates — that is, from the later Ordovicic period — we have but scant records, as will be set forth in the report of Professor Cushing and Doctor Ruedemann. Whether other sediments once covered the slates and were then removed by erosion is doubtful. The lack of sediments suggests land conditions at least for the greater part of the time. The strata shared in the mountainous uplifts to some extent, but near the springs the dips are still very flat and notable folds are not immediately concerned with them. Important faulting has taken place and one fault in particular, as will next be described, has an intimate relationship to the springs. The dips next the faults show a drag down to the southeast on the western side of the break, and an upward drag on the eastern, or dropped side. As the fault escarpments are the more prominent outcrops one could easily gain the impression that the inclination was all to the southeast, but Cushing and Ruedemann find the predominant dips in between the faults to be flat to the west or northwest. The sinking of the surface and of the strata themselves, toward the low points of the region, Saratoga lake and the Hudson river, seems therefore largely due to faulting and to the greater erosion of the soft slates by the continental ice sheet. The geological age of the faults is obscure. They may at least have been the scene of renewed movement in fairly recent geological time.

At some time in this long interval the volcanic plug at Northumberland was developed, but the quarrying operations of the years 1910–11 have revealed some obscure and puzzling relations which will be fully discussed by Professor Cushing in a forthcoming bulletin.

The advent of the Continental glaciers from the north and in very recent geological time has served to spread over the region a heavy mantle of gravel and sand, such that the rocky strata are often buried beneath as much as 150 feet of loose deposits. From the bedrock the natural springs usually emerge into this gravel and sand and then find their way to the surface. Doubtless there are others which have never been discovered and which become lost in the general ground waters. Where they have been observed it has been usual to sink through the gravel to the bedrock, find the orifice and conduct the water to the surface in some sort of a tube which has been cemented tightly to the rock around the crevice.

Various estimates have been made of the time which has elapsed since the recession of the ice sheet. They vary from 10,000 to 50,000 years. If the section revealed in excavating beneath the High Rock mound is correctly interpreted there must have accumulated some 13 feet of tufa and muck since the aborigines built a fire; apparently also since the great ice sheet had scraped the bedrock clear.

THE FAULT AT SARATOGA SPRINGS

A structural feature of the local geology which early claimed attention is the fault which runs along just west of the main line of the springs in Saratoga village. It is revealed by a cliff of Little Falls dolomite some 30 or 40 feet high and with precipitous front except where partially or wholly covered by earth. The fault has been traced by Cushing and Ruedemann to the north across the sheet as their map will show. To the south its exact course is obscured by the glacial drift and sands, but it seems to make a westward swerve at Congress street and Broadway and turn along Oak street after which it may turn south again, but its exact course is hidden by the drift.

The fault as it appears west of the springs along Spring avenue is not one of great displacement. The Little Falls (Beekmantown) dolomite forms the cliff to the westward and possesses the characters of the upper portion of this particular stratum. As it is followed northward beyond the Maple avenue quarries the Amsterdam (Trenton) limestone still remains on top of it, proving that the top of the escarpment is near the upper limit of the dolomite.

At the foot of the escarpment and in the rear of the Star spring bottling works, Cushing and Ruedeman discovered a block of Amsterdam (Trenton) at the surface on the downthrown side. This fixes within fairly close limits the amount of the displacement at this point. If the cliff is about 30 feet and the thickness of the Amsterdam is 50 feet and some of the Amsterdam still remains beneath the surface on the east side, and if its bottom can not have been far above the top of the escarpment on the uplift side, we have 80 feet as an extreme possibility and 50 feet as a not improbable amount.

The displacement may be greater at other places along the fault line, but for so continuous a break it is impressive to find the throw so small. The Amsterdam limestone is soon succeeded by the slates to the eastward.

The most striking feature of the fault lies in the fact that no mineral spring has been discovered to the west of it, and where it can be sharply located no spring is known very far to the east of it. The Strong well is approximately 1100 feet from it; the Excelsior or Ten springs about 3000 feet. The wells of the Natural Carbonic Gas Co. and of the Lincoln Company are some similar distance if we give, as seems necessary, credit to the westward swerve along Oak street. The course of the fault being obscured by the drift, we do not know what its relations to the springs farther south may be. To the north the fault splits into two; the main one following the escarpment of the ancient crystalline rocks and a branch striking northeast toward the Gurn spring. This spring emerges a short distance from the branch fault.

As the springs are not found west of the known fault, it is important to remark that in the region of Saratoga village the slates also fail on this side. The Amsterdam limestone is indeed known, but the slates cease on its east side. Slates are, however, at the surface between the main fault and the Gurn spring branch, but only in limited exposure. Generally speaking, therefore, we may say that both springs and slate lie east of the fault and that the waters of carbonated and saline character apparently belonging to this series of springs have not been discovered more than three-quarters of a mile from its assured outcrop, whereas most of them are where the fault is known and within a few hundred feet of it. In this connection, however, attention should again be drawn to the weak Quaker springs, to Reeds spring in South Argyle, and to the Round Lake well, all of which are some miles east of this particular fault.

The line of springs along Spring avenue, in the village of Saratoga Springs, north and south of the High Rock, are not far from the 280 foot contour. The Hathorn and Congress to the south are a few feet higher but are under 300 feet. The springs west of the steam railway at the Geysers are both above and below the 300 foot contour but do not reach the 320. The Gurn spring is between the 280 and 300 foot contour.

At Ballston Spa, Hides Franklin comes out with a strong pressure at 276, but the other three are below the 260 foot contour.

West of Saratoga Springs and Ballston, the 300 foot contour speedily crosses even the lowest stream valleys and the general level for from two to five miles is between 300 and 400 feet. At Rock City Falls, seven miles due west of Saratoga Springs, the 500 foot contour crosses the main line of drainage, Kayaderosseras creek. Still farther in this direction and within the limits of the quadrangle the altitude attains 1000 feet and to the north, still within the quadrangle, the culmination is about 2000.

By contrast when we turn eastward, Saratoga lake, one important low point, stands at 204 and the Hudson river at 100. With such flat dipping strata even though the commoner dip is to the northwest rather than the southeast, the general course of the ground waters would be to the southeast, and such head as would exist in the normal ground water would be exerted in this direction. William R. Hill C. E., by a careful series of levelings upon the waters standing in the wells of the Natural Carbonic Gas and Lincoln Spring Companies at a time when no pumping was being done and the waters had resumed their normal positions, and by determining the resultant of his observations, reached the conclusion that the natural flow was in a direction s. 65 e. or 25 degrees south of east. While these expressions must be taken as general they undoubtedly express the truth.

GENERALITIES REGARDING THE NORMAL GROUND WATERS

The waters which are found beneath the surface of the earth are now regarded by students of the subject as of three kinds which are technically called:

1 Meteoric, derived from the rainfall.
2 Magmatic or Juvenile, derived from igneous rocks.
3 Connate, which as sea waters and lake waters saturate sediments and are buried with them.

1 **Meteoric waters.** This group embraces the waters of ordinary character and of general occurrence. The rain falls upon the earth and divides into three parts:

a A portion evaporates at once and passes back into the atmosphere.
b A portion runs off on the surface and helps directly to maintain the general drainage.
c A portion sinks into the ground through porous soils, cracks, or other cavities in the rocks and contributes to the "ground water."

The name "ground water" is applied to the subsurface waters which stand at a fairly constant level, wherever the rainfall is sufficient to maintain them, certainly in all but excessively arid regions. The ground water supplies wells, in which it is found in our climate at comparatively shallow depths. It supplies the ordinary springs, and in this way contributes to the drainage, acting as a reservoir and being tapped away at those low points, behind which there is sufficient head to force it to the surface. The movement of this reservoir of water as a whole is very slow, but at individual vents the emerging portion may flow rapidly. Experience in recent years with deep mines and bore holes has led to the belief that as a rule the ground water only attains a depth of 1000 or 2000 feet, since in sinking deep shafts the miners find that by impounding the waters in the upper levels and pumping from them, they pass through the wet zone, and at greater depths have no water at all to pump. Even the small amounts of water required in drilling have to be sent down from the surface or the upper levels. Estimates of the amount of water contained in the outer crust have therefore greatly diminished in later years. Thus, in 1861 Delesse, a French geologist, by assuming a certain porosity for the strata and calculating the amount of water required to fill the cavities, reached the conclusion that, were all this water to be spread over the surface, it would make a layer 7500 feet deep.[1] Estimates by others will be found in the citations. They vary through the following values: C. S. Schlichter 1902, 3000–3500 feet; C. R. Van Hise 1904, 226 feet; Chamberlin and Salisbury 1903, 800 to 1600 feet.

The writer in 1901 endeavored to draw upon mining experience and upon deep boreholes in discussing the ground water and concluded that it extended as a rule to a depth of only 1000 to 2000 feet. If we allow 5 per cent for the voids in rock, this would mean a layer 50–100 feet; or if 10 per cent, 100–200 feet. Ten per cent is the extreme of voids in the most porous and 5 per cent is nearer a fair estimate, but these two values are usually employed.

M. L. Fuller of the United States Geological Survey in 1906, after a very extended experience with holes drilled for water, in his work upon the division of the Survey dealing with water supply, concluded that the ground water would amount to a layer 96 feet deep if it were spread out on the surface. At 5 per cent of cavities in the rocky strata, this would go down about 2000 feet, or at 10 per cent about 1000 feet. T. Sterry Hunt determined the cavities in the hard, white Postdam such as we have at Saratoga Springs to lie between 1.39 and 2.47 per cent of the volume. Less metamorphosed varieties yielded from 6.94 to 9.35. (Chemical and Geological Essays, p. 166, 1878.) These figures will help to make more definite in our minds the amount of water of this kind with which we have to deal.

The meteoric ground waters in their migrations through the rocky strata dissolve some mineral matter. The rain takes up a little carbonic acid gas from the atmosphere and has to this extent its solvent powers increased. It has also oxygen, nitrogen and other gases in far less amount. The dissolved air is higher in oxygen and carbonic acid and lower in nitrogen than is the ordinary atmosphere. Potash, soda, lime, magnesia, and iron dissolve most readily from the rocks. Silica is also taken in very small quantity, as are several other rock-making components. On the whole, lime is the most abundant and widespread of the dissolved bases, and in ordinary spring waters the dissolved matter varies from a minimum of 5 grains to a maximum of about 50 grains per U. S. gallon of 231 cubic inches. These values are practically equivalent to from 85 to 850 parts in a million. If we keep some such general figures as these in mind we can carry along an idea as to the way the mineral springs under discussion compare with ordinary waters. Saratoga waters range from a minimum of 300 to a maximum of about 1200 grains of dissolved solids per gallon.

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[1] M. L. Fuller. Total amount of water in the earth's crust. Water Supply and Irrigation Paper. U. S. Geol. Surv. 160. p. 59, 1906.

Regarding the movement of waters through the crevices of the rocks, the friction greatly increases with the decrease of the diameter of the conduit. Thus if we deal with ordinary pipes, under a constant head, the friction increases inversely as the diameters. A pipe which has a diameter one-eighth that of another, develops eight times as much friction, and the friction operates to lessen the flow greatly.

2 **The magmatic waters.** Observers of volcanic eruptions have long been impressed with the vast amount of steam emitted under great pressure at times of outbreak. The explosive violence of the outbreaks has been chiefly attributed to it. In some instances only such gaseous emissions, together with shattered rock, issue from the crater, as was the case at Mont Pelee, Martinique, except for the solid spine which was forced out in the closing stages. Molten lava failed. Emissions of steam are also yielded, sometimes for months by consolidating lava streams which have already poured out on the surface. The amounts have at times been calculated and they are very impressive.

It was formerly a widespread belief that this water was derived from the ocean or from seas near whose shores volcanos are usually, but not invariably, situated. Geologists imagined that the sea water percolating downward and inward, was drawn by capillary attraction to the molten rock and became involved in its substance. This conception has seemed impossible to many later students of the subject who can not believe that water would or could be drawn through rock gradually becoming hotter and hotter, until the water successively passed its boiling point, its point of dissociation into oxygen and hydrogen and necessarily reached a temperature still higher by 1500 to 3000 degrees Fahrenheit before it could be absorbed by the molten rock. It seems to many at least that as soon as the water encountered temperatures much above its boiling point it would be driven outward. The writer therefore rejects the oceanic source of the water manifested in volcanic eruptions as too improbable to deserve confidence. Water locked up in hydrated silicates which are melted into a rising flood of fused rock might become involved. Possibly confined reservoirs of artesian water which had no escape might also be absorbed, but it seems still more reasonable to think of the water gas, the carbonic acid and the other gases as original component parts of the magma, belonging to it as much as the silica and the common run of bases.

The presence of this water is still further shown by the effects exerted upon limestones where penetrated by masses of molten rock which have never reached the surface. So many new minerals have been produced partly from the limestone and partly by contributions from the igneous mass, that the agency of magmatic waters has been invoked by almost all students of the subject in order to explain the results.

In regions of dying volcanic activity, hot springs and emissions both of carbonic acid gas and of carbonated waters are the rule. Where the composition of the waters is markedly different from the composition of the rocks through which they rise, some observers have seen reason to attribute to them a deep-seated magmatic source. Carlsbad, Bohemia, with its springs rich in lime, arising from granite, a rock extremely poor in lime, is a famous case in point. Deep-seated magmatic waters have seemed to some observers the simplest explanation.

The waters are presumably evicted from the molten mass in its process of crystallization into the anhydrous silicates which make up the ordinary igneous rock. Obviously existing first as gases in the deep-seated mass, they pass with loss of heat into the liquid form and furnish hot springs and in their later stages possibly cold ones. The waters were called "juvenile" by E. Suess, the venerable Austrian geologist, because they reach the surface for the first time and therefore are young, or newly born. In America the name magmatic is somewhat more current.

In the most recent of the more important contributions to this subject,[1] P. Brun gives a number of analyses of gases which he has collected from regions of dying volcanic activity. He fails to find water gas in notable quantity, but does detect much hydrochloric acid. He concludes that the vapors which have been hitherto observed arising from volcanic vents are ammonium chlorid and other gases, together with finely divided dust, but not steam. Mr Brun's results have made a deep impression and so far as they go, are opposed to magmatic waters. They are however so different from the hundreds of analyses made before him by competent chemists, that many, including the writer, still adhere to the views set forth above.

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[1] P. Brun. Recherches sur l'exhalaison volcaniques, Geneva, 1911. The work is summarized in English by Alex. Winchell in Economic Geology.

We have as yet no sharp chemical criteria with which to distinguish magmatic waters from meteoric, except perhaps that carbonic acid is, as a matter of observation, when present in copious supply, usually in a region of dying volcanic activity. F. C. Lincoln has made a careful review of the records and has arranged the results in fifty representative analyses. He then finds that the gases when averaged from the fifty cases are, in the order of abundance, and expressed in parts per hundred:

Nitrogen (N_2)	44.360
Carbon dioxid (CO_2)	36.303
Oxygen (O_2)	9.026
Sulfuretted hydrogen (H_2S)	4.991
Hydrochloric acid (HCl)	2.057
Hydrogen (H_2)	1.601
Sulfur dioxid (SO_2)	.966
Marsh gas (CH_4)	.638
Carbon monoxid (CO)	.032
Ethane (C_2H_4)	.001

Of the nongaseous matters, water is much the commonest, constituting up to 95 per cent of the total condensed. In the above figures some, probably a rather important portion, of the nitrogen and oxygen is due to the admixture of atmospheric air in the sample. Since carbon dioxid only forms .03 per cent of atmospheric air, very little of it can have been derived from this source.

These statements regarding the magmatic waters are made, not with the idea of presenting a brief in their advocacy, but because they are significant and must be considered in any discussion of mineral springs.

3 **Connate waters.** Connate is a name recently applied by A. C. Lane to those waters which are, so to speak, born with the rocks which contain them, and which, absorbed by sediments during deposition, are carried down with the sediments when the latter are buried beneath other accumulations. If the sediments are marine, oceanic

waters will remain in them. If they are lacustrine, fresh water will be absorbed. The common brines found by the drill in old marine deposits are undoubtedly connate, but their preservation is largely due to being inclosed between impervious beds above and below. When we deal with fresh-water sediments the connate waters do not have great difference in composition from the ordinary meteoric ground waters. In judging of marine connate waters it is important to bear in mind that some geologists think the sea to have been a less concentrated solution in its early history, and in the very remote times represented, for instance by the Grenville series of the Saratoga section, that it was comparatively fresh. Rivers have indeed been pouring into it their burden of dissolved materials and as these are not removed by evaporation, except to the extent in which they are driven over the land in spray caught up from breaking waves by the wind, the conclusion has followed that the sea is like a great evaporating pan, constantly becoming more concentrated. One line of attack upon the problem of estimating the age of the earth has been to assume fresh-water oceans and calculate from the known composition and volume of rivers the time required to bring the oceanic waters up to their present concentration.

On the other hand, there are geologists, notably Edouard Suess in Vienna, and R. T. Hill in New York, who urge that the oceans themselves were fed by magmatic waters from volcanos or their equivalents, in the early history of our planet, and that, as is well known regarding some volcanic waters, the salt was also furnished in this way. These views are at least worthy of respect; they seriously affect calculations of the age of the earth, although they do not conflict with the belief in weaker oceanic waters in the remote past. Connate waters underground almost inevitably are subject to admixtures of meteoric ground waters.

THE COMPOSITION AND CHARACTER OF THE SARATOGA WATERS

Having established the general conceptions regarding underground waters, we may next take up the composition of the local mineral springs and their place among mineral waters as found in nature. Many analyses have been prepared in the last seventy-five years or more and a considerable number within the last ten. A few introductory remarks may be made upon analyses in general and the methods of reporting the results, before the actual waters are discussed.

The analysis of a water is conducted by taking a suitable and carefully measured sample from the spring and evaporating it to dryness so as to secure the dissolved matter. The composition of the evaporated residue is then determined by the chemist. It must be remembered that the residue from a water such as is afforded by the Saratoga springs is a complex mixture containing a number of bases and acids, each of which is determined by itself. Thus in the Saratoga waters there have been customarily reported ten elements which are present in acids, namely, chlorin, bromin, iodin, fluorin, carbon, sulfur, phosphorus, boron, nitrogen and silicon. Each of these makes an acid of its own. Some ten elements furnish the bases, namely, sodium, potassium, lithium, magnesium, calcium, barium, strontium, iron, aluminum and manganese. With these must be placed the rarer ammonium and still rarer rubidium. When the chemists have determined these acids and bases they endeavor to combine the results as they believe them to exist in the original water. They do so on assumptions of the relative chemical affinities of the elements for one another and divide the acids among the bases so as to use up the supply of each. Probably the results represent with a fair degree of accuracy the combinations as found in the springs, but as subsequent discussion will show, there inevitably arise minor differences among chemists.

In later years the theory of ions has gained great support. According to this conception, the dissolved compounds exist in dilute solutions in the form of incomplete molecules, the same being held in this condition by electromotive force. The incomplete molecules are called ions. Thus, whereas in an older analysis, we would find reported $NaCl$, Na_2CO_3, (or $NaHCO_3$), $NaBr$, NaI, Na_3PO_4, KCl, K_2SO_4, $MgCO_3$ (or $Mg(HCO_3)_2$), $CaCO_3$ (or $Ca(HCO_3)_2$), CaF_2, $FeCO_3$ (or $Fe(HCO_3)_2$), $BaCO_3$ (or $Ba(HCO_3)_2$), Li_2CO_3 (or $Li(HCO_3)$), $SrCO_3$ (or $Sr(HCO_3)_2$), Al_2O_3, and SiO_2; in one in the last ten years we find, Cl, HCO_3, Br, I, PO_4, SO_4, Na, K, Mg, Ca, Fe, Ba, Li, Sr, Al and SiO_2. As a separate statement the latter authority might then combine them into salts but whereas as the earlier chemists sometimes calculated carbonates, such as Na_2CO_3, $MgCO_3$, $CaCO_3$, etc., the later analysis gives them all as bicarbonates, respectively $NaHCO_3$, $Mg(HCO_3)_2$, $Ca(HCO_3)_2$, etc. Each chemist determined boron — the former combined it with sodium as a biborate; the latter as a metaborate.

There is no very serious objection to either of these courses as above outlined. Fashions change among chemists as among other people, but the method of reporting by ions probably involves fewer possibilities of mistaken assumptions. People at large, however, are not yet accustomed to these terms and an analysis in the newest form possesses for most readers less significance than one in the old style.

There are other differences in the methods of reporting analyses. The older method and the one most widely intelligible among those not skilled in chemistry, is to give the dissolved matter in grains per U. S. gallon of 231 cubic inches. More rarely, older analyses are expressed in grains per Imperial gallon of 277.272 cubic inches. The U. S. gallon contains 58,373[1] grains; the Imperial, 70,048.4 grains. Both involve the old system of apothecary's weights. In later years it is a growing custom to express the analysis in parts per million, a method which falls in best with the metric system, in which the analyses are universally made. We can roughly pass from the grains per U. S. gallon to parts per million by multiplying the former by 17,[2] or from parts per million to grains per gallon by dividing by 17. The writer much prefers parts per million, which is of course in the metric system milligrams per liter. Enough parallel values will, however, be given to make the statements significant to one accustomed to grains per gallon.

It may further be remarked that the total of solids actually weighed after evaporation of the sample is necessarily always less than the summation of the dissolved salts, where the latter are given as bicarbonates. The extra carbonic acid molecule or partial molecule of the bicarbonate passes off in evaporation.

Among the analyses made of the Saratoga waters in the last hundred years three groups may be established:

The oldest were principally performed by Dr John H. Steel, a physician resident of Saratoga Springs in the early years of the past century, and the first one to give the waters thorough scientific study. Doctor Steel published a book on the springs[3] in which he brought together a series of analyses made in the 30's or earlier. With these in the chart, figure 2, have been combined a few others of this early time or of the next decade. All these analyses are compiled in the tables at the close of this bulletin.

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[1] A. C. Peale, in his paper on the Mineral Springs of the United States in 14th Ann. Rept. U. S. Geol. Survey, p. 71, gives a U. S. gallon as 58,372 grains and the Imperial as 70,000 or 277 cubic inches.

[2] More accurately by 17.13. The reciprocal is .058.

[3] John H. Steel M. D. An Analysis of the Mineral Waters of Saratoga and Ballston, with Practical Remarks on their Medical Properties, etc. Saratoga Springs, 2d ed. 1838. Earlier imprints appeared in 1817 and 1825. The 1825 edition has a geological map. The strata are classified as: I Primitive class — granite, gneiss, syenite, mica slate and soapstone; II Transition class — argillaceous slate and gray-wacke; III Secondary class — compact limestone. A copy with the map is in the New York Public Library.

The second group was made about thirty years later. Just before and just after 1870, Dr Charles F. Chandler prepared a very valuable list, representing nearly all the better known springs both in Saratoga and Ballston. They were chiefly published in the "American Chemist" for December 1871, page 203. As used here they are amplified by one or two made in 1871–73 which appear in Cairn's Quantitative Analysis. In 1905 or thereabouts the United States Department of Agriculture through its Bureau of Chemistry prepared an interesting series in connection with the investigation of mineral waters placed on sale throughout the country. Some of the samples were bought in the open market and a still larger series was obtained at the springs by a representative of the bureau.

Besides the analyses used in the charts, a number have been prepared at the request of owners of springs by chemists of standing and have been used in circulars or other advertising matter. They, so far as available, and all the ones used in the charts, have been compiled in the tables of analyses on pages 65–74. They are less significant than groups made by the same chemist, whose sampling and methods would be naturally more uniform, but they have value. One must also hold judgment somewhat in abeyance as regards the significance of analyses because of the artificial strengthening of natural waters both with salts and with carbonic acid. To some extent this has been done.

In all the general statements which follow, the total of dissolved solids is based on bicarbonates. These results, therefore, as earlier stated, will be somewhat higher than the weight of the residue obtained by evaporation. The extra molecule of carbonic acid is driven off on evaporation. The bicarbonate, however, probably represents the salt as it exists in solution. In the first set of curves only the most abundant of the dissolved salts are used, namely, $NaCl$, $Ca(HCO_3)_2$, $Mg(HCO_3)_2$ and $NaHCO_3$. The others will be commented upon but are too small to make much of a showing when plotted as curves.

In total dissolved solids the maximum found in the Saratoga waters by the earlier analysts is 11,215 parts in a million, reported for the Congress spring in 1843, by J. R. Chilton. The minimum is 3787, reported by J. H. Steel for the New Washington.

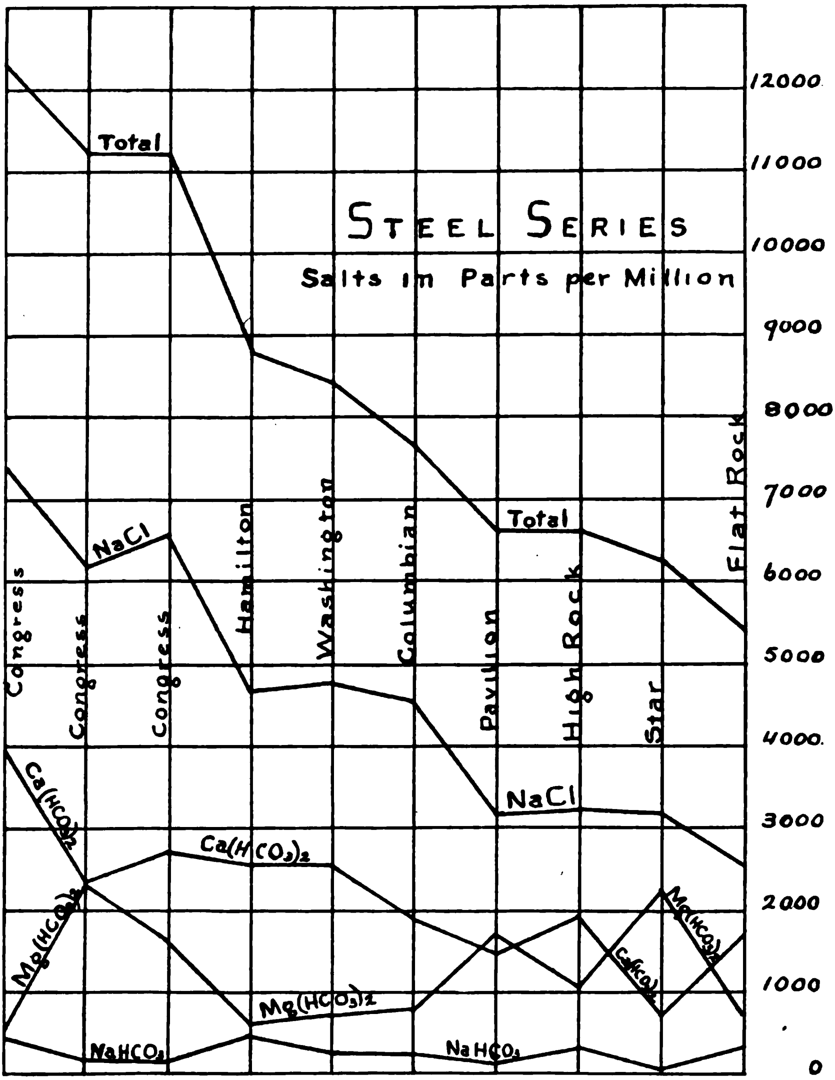

Figure 2 Diagram of dissolved salts based on the analyses of Dr John H. Steel, 1838. The horizontal lines indicate parts per million. Each vertical line represents one analysis.

In the series made by Dr Charles F. Chandler just before and just after 1870 the maximum was afforded by the Glacier Spouting well, at 20,325 parts in a million, or about 2 per cent. Next to this is the Geyser Spouting well with 16,856. The minimum was afforded by the Seltzer spring with 5134 parts.

In the series from the Department of Agriculture, the maximum is the Carlsbad, with 12,950; the minimum, the High Rock, with 2347.

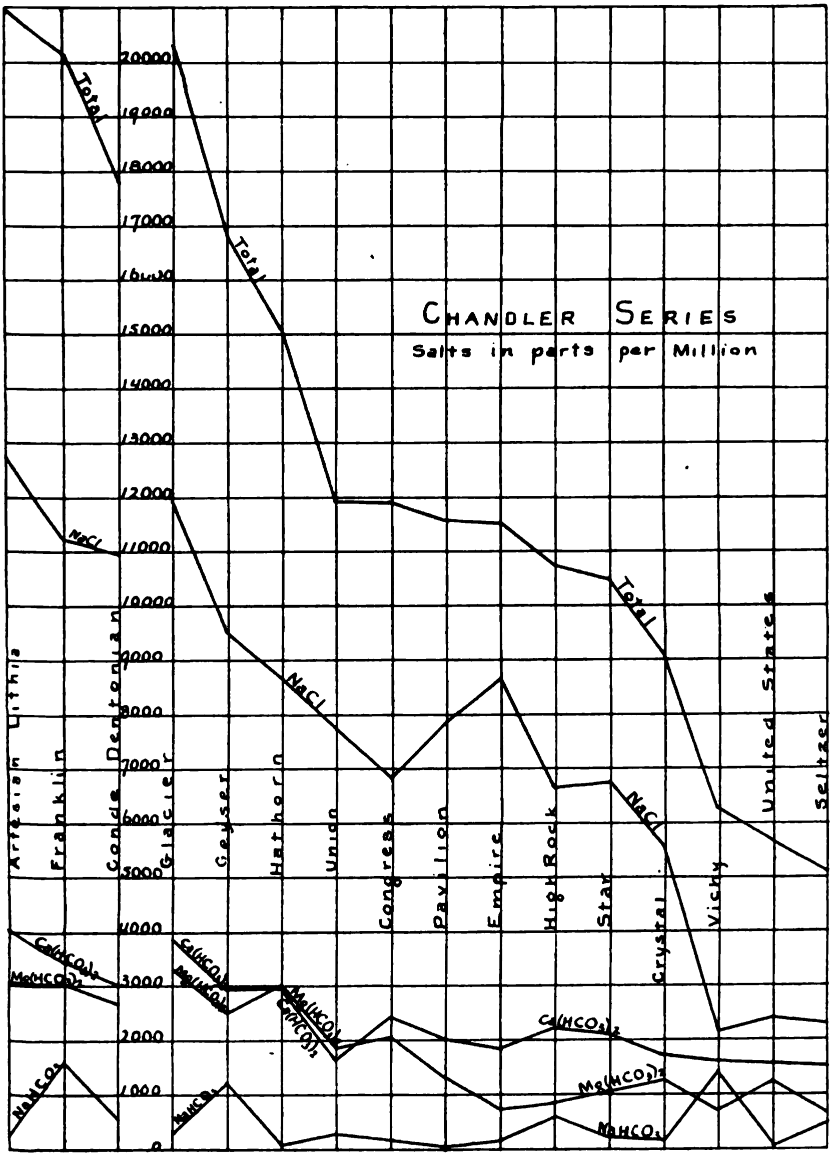

Figure 3 Diagram of dissolved salts based on the analyses of Dr Charles F. Chandler, 1873 The horizontal lines indicate parts per million. Each vertical line represents one analysis.

The State Department of Health has found in the new Hathorn No. 2, two miles or more south of the village, 16,350, and in the Champion spring only 1370.

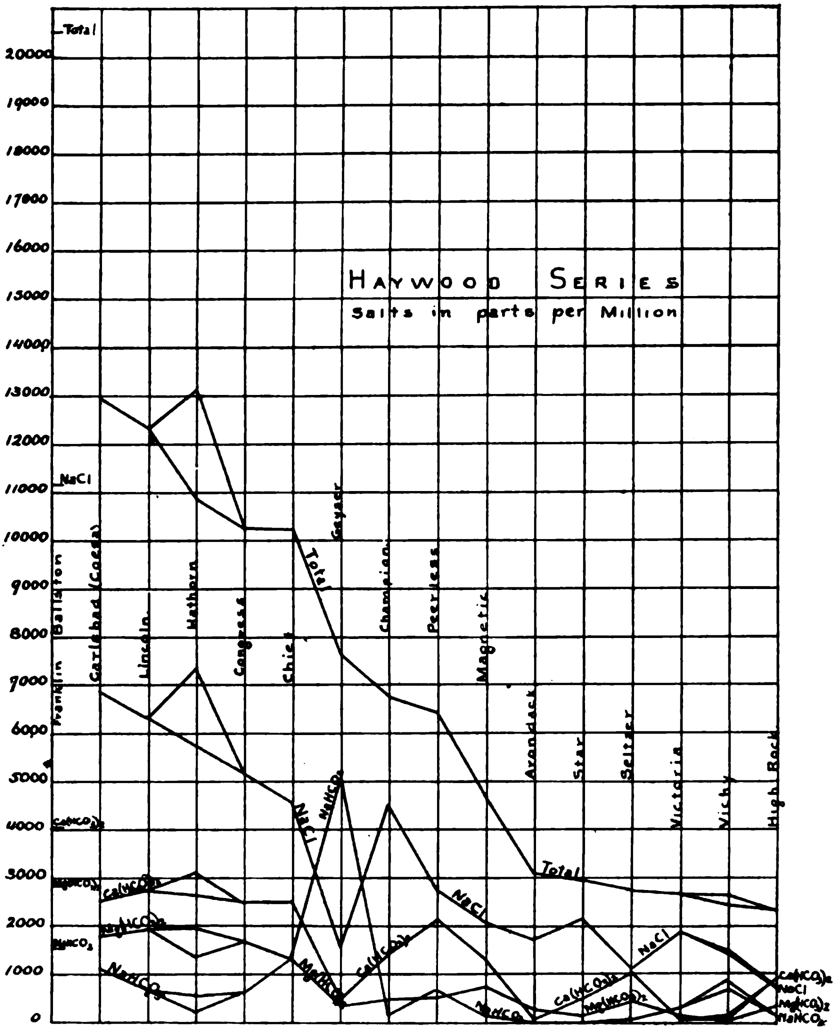

Figure 4 Diagram of dissolved salts based on the analyses of J. K. Haywood and B. H. Smith, of the United States Department of Agriculture, 1905. Each horizontal line indicates parts per million Each vertical line represents one analysis.

The Ballston waters give higher results than any above cited. Doctor Chandler found in the Artesian Lithia spring 20,965, and in the Franklin 20,134. An analysis recently made of the latter spring by the Department of Agriculture gave 20,542.

These values will establish some conceptions of the extremes. A study of the diagrams will give a better impression of the mean or general composition. While not capable of definite expression, one finds it nevertheless helpful to formulate a general idea of this sort. Where, upon the charts, the curves take an approximately horizontal course, they indicate a number of analyses of nearly the same character, and if this feature is specially marked, values fairly typical of Saratoga may be looked for. In the oldest set of eight different springs, the totals of six lie between 6000 and 9000 parts in a million (353 to 530 grains to the gallon). In Doctor Chandler's series of thirteen analyses, representing a range from 5000 to 20,000 parts per million, six lie between 10,500 and 12,000. In the thirteen from the Department of Agriculture, there is an almost even decline from the maximum, about 13,000 down to 3100. There are then six between 2300 and 3100.

In every analysis known to the writer, save one, $NaCl$ or common salt is the most abundant of the dissolved ingredients. The solitary exception is an analysis of Geyser water, made by the Department of Agriculture, in which $NaHCO_3$, sodium bicarbonate, 5058 parts, is more than three times the $NaCl$, sodium chlorid, 1588 parts. The Geyser water, however, as analyzed by Doctor Chandler, was normal. The analysis with the high percentage of sodium bicarbonate possesses more human than scientific interest. Except for this exceptional case the $NaCl$ curve is with small variations sympathetic with the curve of total dissolved matter. The $NaCl$ is from two and one-half to three times as abundant as the next salt, calcium bicarbonate, $Ca(HCO_3)_2$. The maxima and minima of $NaCl$ are: earliest set—7385 and 2531; Doctor Chandler's set—11,938 and 2187; Department of Agriculture—6873 and 738.

Next to the $NaCl$, the calcium bicarbonate, $Ca(HCO_3)_2$ and the magnesian bicarbonate $Mg(HCO_3)_2$ are the salts chiefly in evidence. They may best be discussed together. They display marked sympathy with each other, the $Mg(HCO_3)_2$ being usually somewhat less than the $Ca(HCO_3)_2$. Among the older analyses, the maxima are for the calcium and magnesium salts, respectively, 3966 and 2325. The minima are 714 and 544. In the analysis of the Star water, however, E. Emmons reports 714 and 2218, respectively, a relation which is extraordinary, as the subsequent analyses of Star water are both normal. Probably the separation of calcium and magnesium in the analysis was faulty. In Doctor Chandler's series, the maxima are respectively 3860 and 3297; the minima 1528 and 685. In the Department of Agriculture series, 3098 and 1974; the minima 36 and 55.

In the oldest series of eight different waters the magnesium salt exceeds the calcium salt twice; in the Chandler series of thirteen waters, twice; in the Department of Agriculture series of fifteen waters, also twice, but each time in very small amounts, 104 to 236 and 36 to 130.

Since these heavily carbonated waters are immediately derived from a dolomitic limestone and are vigorous, natural solvents of both calcium and magnesium carbonate, the two salts are doubtless derived in very large part from the limestone. Their solubilities in carbonated waters are respectively at pressures of one atmosphere, 385 and 1310 per million for non-crystalline varieties.

Of the ratio of the calcium carbonate, $CaCO_3$, to the magnesium carbonate, $MgCO_3$, in the Little Falls dolomites we can not speak with accuracy, because different layers probably differ, but the rock undoubtedly has the calcium salt uniformly in excess of the magnesium. In pure dolomite the calcium carbonate bears a ratio to the magnesium carbonate of 1 to .768. In Doctor Chandler's series the ratios lie between 1 to .417 and 1 to 1.13; in the Department of Agriculture's between 1 to .255 and 1 to 3.61, but in the last case the quantities are very small, 36 and 130 parts per million respectively.

While in very small amounts and therefore not plotted in the charts the presence of barium and strontium bicarbonates with the closely related calcium salt should be mentioned. Strontium was detected by one of the early chemists and is mentioned as a trace; barium, however, escaped notice. In the Chandler series barium bicarbonate is mentioned in many analyses and varies from upper values of 35.4 parts in the Glacier Spouting well and 34.2 in the Geyser, respectively 2.08 and 2.01 grains per gallon, to a trace in the Seltzer. Strontium bicarbonate is rarer. While invariably reported its maximum was 7.2 parts in the Geyser (.425 grains per gallon) but it was only a trace in ten out of thirteen analyses. Obviously it is present in very small proportions. In the analyses from the Department of Agriculture the maximum barium bicarbonate was found in the Lincoln water, 22.1 parts in a million, but strangely with no strontium whatever. The values of the barium salt are then pretty well distributed in the other analyses down to none at all in two of the seventeen. Strontium bicarbonate was never found above a trace in seven analyses, and failed altogether in ten.

The last salt found abundant enough to plot on the charts was the bicarbonate of soda, $NaHCO_3$. In the oldest series of analyses it favors very small values, the maximum being 359 parts, the minimum, 54.4. In the Chandler series the maximum is 1409, the minimum 64.6. In the Department of Agriculture series we find the exceptional Geyser water with 5058, which may be rejected from serious consideration. Next to it is the Chief, 1367. In two none is reported whatever.

Following the salts mentioned, potassium chlorid, KCl, is the one which on the whole next merits attention. In the earliest analyses it was seldom calculated. Only one record has been made and that of the Red spring, 116.6 parts in a million (6.86 grains in a gallon) by Professor Appleton. Such little potassium as was reported by the early chemists was usually combined with bromin, but many times we find no mention of it at all. In the Chandler series potassium chlorid is uniformly reported and fails in no analysis. Its maximum is 686.5 parts per million (40.4 grains per gallon) in the Glacier Spouting well. Its minimum 22.1 (or 1.3 grains) in the Seltzer spring. Among the thirteen analyses one is between 600 and 700; one between 400 and 500; one between 200 and 300; eight between 100 and 200; and two less than 100. Obviously, the common experience is between 100 and 200, or between 6 and 12 grains per gallon. In the Department of Agriculture series of seventeen analyses potassium chlorid is uniformly reported; one, the maximum, exceeds 400 (Carlsbad water 415); five fall between 300 and 400; two between 200 and 300; two between 100 and 200; and seven below 100, the minimum being 7.2. A comparison of these two statistics leads to no very tangible conclusion.

In the earlier analyses the next salt in abundance after sodium bicarbonate is iron bicarbonate, more often reported as iron carbonate. It appears in thirteen out of sixteen analyses. If we express it uniformly as bicarbonate we find that in six analyses it exceeds 100 parts in a million (maximum 148.2); in seven analyses it is below 100, the minimum being a trace. In the Chandler series iron bicarbonate is uniformly reported. Its maximum value is 43.7 parts per million, its minimum is .9. In the Department of Agriculture series the iron is sometimes given as bicarbonate and sometimes as ferric oxid with alumina. The maximum of the bicarbonate is 132.9, the minimum, none at all, that is no iron whatever was found in one case. Where expressed as the oxid with alumina, the maximum is 80 in the same sample as the maximum bicarbonate.

It may be remarked that in the later development of the springs, deep-drilled holes are increasingly abundant and are cased with iron pipe. A small trace of iron might thus be contributed, as we are in any event dealing with quantities extremely small.

Iron in any form is not specially welcome to the purveyors of table waters, because, on standing, it separates as the hydrated ferric oxid and imparts a brown cloudiness to the water. This can be prevented by the slight addition of some harmless acid, such as citric, which keeps the iron in solution.

Manganese is an element so closely akin to iron that it may be mentioned here. It is not reported in any of the older analyses nor in the Chandler series, nor in the ones by other chemists recorded by A. C. Peale in Bulletin 32 of the United States Geological Survey. In the Department of Agriculture series it is but once mentioned as a trace.[1] Two analyses are quoted in "Our County and its People," page 401, of the Putnam spring. 8.23 parts per million (.484 grains per gallon), Lincoln spring 1.72 parts (.101 grains per gallon), but the analysts are not given.

Obviously the amount is very small and practically negligible as a factor in the general total.

The haloid elements bromin and iodin were very early discovered. Both are almost always mentioned in the older series of analyses. The bromin was usually assigned to potassium and expressed as potassium bromid. While ordinarily a mere trace, when combined with sodium iodid the sum for the Congress spring in one case was 100.6 parts in a million (5.92 grains in a gallon). Sodium iodid ranges from 30 to 60 parts per million with a maximum reported for the Empire spring by E. Emmons of 204 (12 grains per gallon).

In the Chandler analyses the bromin and iodin when recast were both assigned to sodium, all the potassium being given as chlorid or sulphate. The maximum elementary bromin is 112.9 parts per million (6.64 grains per gallon) equivalent to 145.5 parts of sodium bromid (8.56 grains per gallon) in the Congress spring. The minimum is 1.82 (.107 grains per gallon), corresponding to 4.52 (.266 grains) sodium bromid in the Empire. The maximum elementary iodin is 8.67 parts (.51 grains) or expressed as sodium iodid, 10.30 parts (.606 grains) in the Empire. The minimum is a trace.

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[1] In the analysis of the Seltzer water, page 92, Bulletin Bureau of Chemistry, no. 91, it is calculated as Mn_3O_4. 7.3, although not mentioned in the elementary analysis which has the same total.

In the Department of Agriculture series the maximum elementary bromin is 76 parts in a million, corresponding to 113 parts of potassium bromid, in the Lincoln spring. The minimum was a trace in the Vichy spring. All these analyses are recast to the potassium salt. The iodin is much less. Its maximum elementary is 1.9, corresponding to potassium iodid 2.5 in the Lincoln. Its minimum is none at all.

The remaining haloid element, fluorine, was not reported in any of the earlier analyses, but it is almost always mentioned as a trace and assigned to calcium as calcium fluorid in the Chandler series. Fluorine is not mentioned in the analyses from the Department of Agriculture. Obviously when present its amount is extremely small, almost beyond the detection of ordinary analysis.

The presence of sulphates was noted by the early chemists who mention them in four out of sixteen analyses. In these, the sulfuric acid is assigned to sodium sulphate (Na_2SO_4) and ranges in amount from 28.56 parts in a million to 11.0 (1.68 grains in a gallon to .65). In one case it was calculated as magnesium sulphate, with .85 parts (or .05 grains). In the Chandler series it is always assigned to potassium sulphate and varies from 91.8 parts in the Star spring to a trace in several others (5.4 grains to a trace). In the Department of Agriculture series sodium sulphate is used. The maximum is 444.9 parts (26.2 grains) in the Arondack water, and the minimum 2.1 parts (.12 grains) in the Geyser.

Lithium is an element whose presence is greatly desired by the purveyors of mineral waters because of its supposed medicinal value. It does not fail in the Saratoga waters, but is in the customary small amounts. It was reported in only one case by the older chemists, in the Red spring, with 16.6 parts of lithium bicarbonate in the million (.94 grains in a gallon). As the bicarbonate it is mentioned in weighable amounts in all the Chandler analyses, varying from 194.6 parts in a million in the Hathorn (11.45 grains per gallon) to 15.3 as the lower limit (.9 grains per gallon) in the Seltzer. In the Department of Agriculture series the lithium is recast as lithium chlorid which is about six times the elementary lithium, whereas the lithium bicarbonate is nearly ten times. The maximum lithium chlorid reported is 44.9 parts in a million, but in a later analysis of the same water only 3 parts were found. In the seventeen analyses, two lie between 30 and 40 parts; one between 20 and 30; four between 10 and 20; and eight are less than 10, one being a trace. These figures mean from a maximum of 2.64 grains in a gallon, to a trace.

Phosphoric acid was detected in two cases by the early chemists and was assigned to calcium as $Ca_3(PO_4)_2$ each time by the same chemist. The amounts were 3.57 and 3.23 parts per million of calcium phosphate. In the Chandler series the phosphoric acid is assigned to the sodium, and when reckoned as sodium phosphate ranges from a maximum of .44 parts in a million (.026 grains in a gallon) to a trace in five out of thirteen cases. In the Department of Agriculture series the phosphoric acid radicle (PO_4) was only found once in seventeen cases; all the rest gave none. Calculated as calcium phosphate $Ca_3(PO_4)_2$ it was 3.8 parts in a million (.22 grains per gallon).

Boron in some form of boracic acid has been occasionally reported. None of the older chemists detected it. In the Chandler series it is calculated as biborate of soda, and is reported as a trace in every analysis, never exceeding this value. In the analyses from the Department of Agriculture none at all was found in three of the seventeen cases, but in the other fourteen it varies from a small amount to a trace. It was in no case actually weighed as its determination in small quantities is difficult.

Alumina was recognized by the early chemists and was reported in seven out of sixteen analyses. Its maximum was 26.69 parts in a million (1.57 grains in a gallon) in the Union spring and its minimum a trace in three cases. It is always mentioned in the Chandler series and varies from a superior value of 20.8 parts in a million (1.22 grains per gallon) in the High Rock, to a trace in three cases. The analyses of the Department of Agriculture are not expressed so as to be of much service. Elementary aluminum is combined with elementary iron. These are sometimes recast as the combined oxids, and sometimes a portion of the iron is apparently assumed and calculated as bicarbonate. The combined elements range from a maximum of 97.8 parts in a million (5.8 grains per gallon) in the Magnetic (partly recast as 80 parts Fe_2O_3, Al_2O_3, and 132.9 parts $Fe(HCO_3)_2$) to a minimum of .8 (.05 grains per gallon) in the Champion. The Magnetic spring is, however, very exceptional. The next value to it is 14.7, so that the general range is approximately from 15 to 1.

Silica was recognized by the early chemists and was mentioned in eleven out of sixteen cases. It ranged from 55.25 parts in a million (3.25 grains per gallon) to a trace. It is always reported by Doctor Chandler and has a maximum of 54.6 parts per million (3.2

grains per gallon) in the Crystal spring and a minimum of 11.3 parts (.66 grains per gallon) in the Geyser. In the Department of Agriculture series, silica is always reported. Its maximum of 42.7 parts (2.5 grains) is in the Magnetic. The minimum of 9.2 parts (.54 grains) is in the Arondack. The values are quite uniformly distributed between these values. Once in the Vichy spring, a portion of the silica is recast into 27.6 parts of calcium metasilicate, CaO,SiO_2.

In one of the older analyses, made by J. R. Chilton of the Washington spring, 3.4 parts in a million (.2 grains per gallon) of calcium chlorid, $CaCl_2$, are reported, and 11.56 parts of magnesium chlorid, $MgCl_2$ (.68 grains), but the later analysts do not estimate these salts. Aside from the ones already passed in review, no other determinations of solids were made by the early chemists.

In the Chandler series organic matter is mentioned as a trace in every analysis, but no other solids are recorded than the ones already discussed.

In the series from the Department of Agriculture organic matter as such does not appear, but several determinations not reported in the two earliest groups of analyses are mentioned. Ammonium was found in every case and when expressed as ammonium chlorid, NH_4Cl, it ranges from a maximum of 39.67 parts in a million in the Carlsbad water (2.33 grains per gallon) to a minimum of .15 parts in the Victoria. The radicles of both nitric (NO_3) and nitrous (NO_2) acids are uniformly given. When recast as sodium nitrate, $NaNO_3$, we find 60.7 parts for the Star, followed by 16.3 for the Arondack, 9 for the High Rock, 6 for the Seltzer and a trace or none at all for the other thirteen. Sodium nitrite, $NaNO_2$, appears as 44.3 parts per million likewise for the Star, 11.9 for the Arondack, 6.6 for the High Rock, 4.4 for the Seltzer, and a trace or none for all the rest. Occasionally in analyses of other chemists whose work is not used in the above review, potassium nitrate is mentioned but the amount is always small. The presence of these salts in notable amount is so exceptional in the waters as to raise a query in the minds of close students.

The above review will make clear in a general way the ranges of composition in dissolved salts as shown by the waters at different times and by different chemists. The current remarks will bring out also the variations of waters of this type and the changes in the course of some seventy-five years, except in so far as the obvious gradual weakening may have been compensated in later time by artificial additions. A brief summary and tabulation of the maxima and minima may now be given. All the values are in parts per million. Divide by 17 for grains per gallon.

Salt.	EARLY ANALYSES 1820–1850		C. F. CHANDLER 1860–1875		DEP'T OF AGRICULTURE 1902–1905	
	Max.	Min.	Max.	Min.	Max.	Min.
Total solids	11,215	3787.	20,325	5134.	12,950	2347.
NaCl	7385	2531.	11,938	2187.	6873	738.
KCl	116.6		686.8	22.1	415	7.2
KBr NaI	100.6	tr.				
NaI	204.		10.30	tr.		
NaBr			145.5	4.52		
KBr					113.	tr.
KI					2.5	None
LiCl					44.9	tr.
NH4Cl					39.67	.15
CaF_2			tr.			
$CaCl_2$	3.4					
$MgCl_2$	11.56					
$Ca(HCO_3)_2$	3966.	714.	3860.	1528.	3098.	36.
$Mg(HCO_3)_2$	2325.	544.	3297.	685.	1974.	55.
$Ba(HCO_3)_2$			35.4	tr.	22.1	None
$Sr(HCO_3)_2$	tr.	tr.	7.2	tr.	tr.	None
$Fe(HCO_3)_2$	145.2	tr.	43.7	.9	132.9	None
$Mn(HCO_3)_2$					tr.	None
$NaHCO_3$	459.	54.4	1409.	64.6	5058. 1367.	None
$LiHCO_3$	16.		194.6	15.3		
Na_2SO_4	28.56	11.			444.9	2.1
K_2SO_4			91.8	tr.		
$MgSO_4$	.85					
$NaNO_3$	28.56				60.7	None
$NaNO_2$					44.3	None
$Ca_3(PO_4)_2$	3.57				3.8	None
$Na_6(PO_4)_2$			.44	tr.		
$Na_2B_2O_4$			tr.	tr.		
$NaBO_2$					small amt.	None
Al_2O_3	26.69	tr.	20.8	tr.		
Al_2O_3, Fe_2O_3					80.	
SiO_2	55.25	tr.	54.6	11.3	42.7	9.2
$CaSiO_3$					27.6	None
Organic matter			tr.	tr.		

Besides the compounds quoted in the three series of analyses, one may find in the occasional commercial analysis the following additional ones: calcium sulphate, potassium nitrate, potassium silicate, sodium silicate, boracic acid and ortho-silicic acid. The only additional element is rubidium which, as the chlorid, is cited as a trace in an analysis of the Sans Souci spring of Ballston in "Our County and its People," page 408, no chemist being mentioned.

As stated in the general remarks on chemical analyses, there is much room for assumption in recasting analyses to compounds. It will be of interest therefore to summarize briefly the relative abundance of the elements or acid radicles. The values will be taken only from the Chandler series of analyses and those of the Department of Agriculture. In all cases the chlorine is the most abundant elementary substance, except in the extraordinary instance of the Geyser analysis in the latter series, whose sodium bicarbonate proportion is so high as to give it no scientific value. The sodium follows after the chlorine, and as a rule the calcium and magnesium come next, the calcium usually in excess. Potassium is next and is succeeded by bromine, barium and lithium. The other elements are very small. Ammonium although not an element, behaves like one, and in the Department of Agriculture series on the whole ranks barium. Silica, also not elementary, precedes barium. Iron and aluminum together come approximately between silica above and barium below. If we calculate the carbonic acid of the bicarbonates as HCO_3 it may, in waters with high lime and magnesia, exceed the chlorin and be the highest value of all. If we consider also the gas that escapes, it is the most abundant dissolved substance as the water exists two or three hundred feet beneath the surface.

Since it is difficult to follow variations of so many substances, a series of curves has been plotted and is shown in figures 5–8 inclusive. Analyses are sometimes prepared of the evaporated residues. They are then expressed in percentages of the total residue. They are very significant in being simpler than parts per million in the water itself. They also enable one to judge critically the amount of the commoner ingredients. As the concluding table of analyses at the close of this bulletin (p. 75, 76) a compilation of those which have appeared up to date is given. It was chiefly made by Mr J. C. Minor, jr. To Mr Minor's records one or two recent analyses have been added.

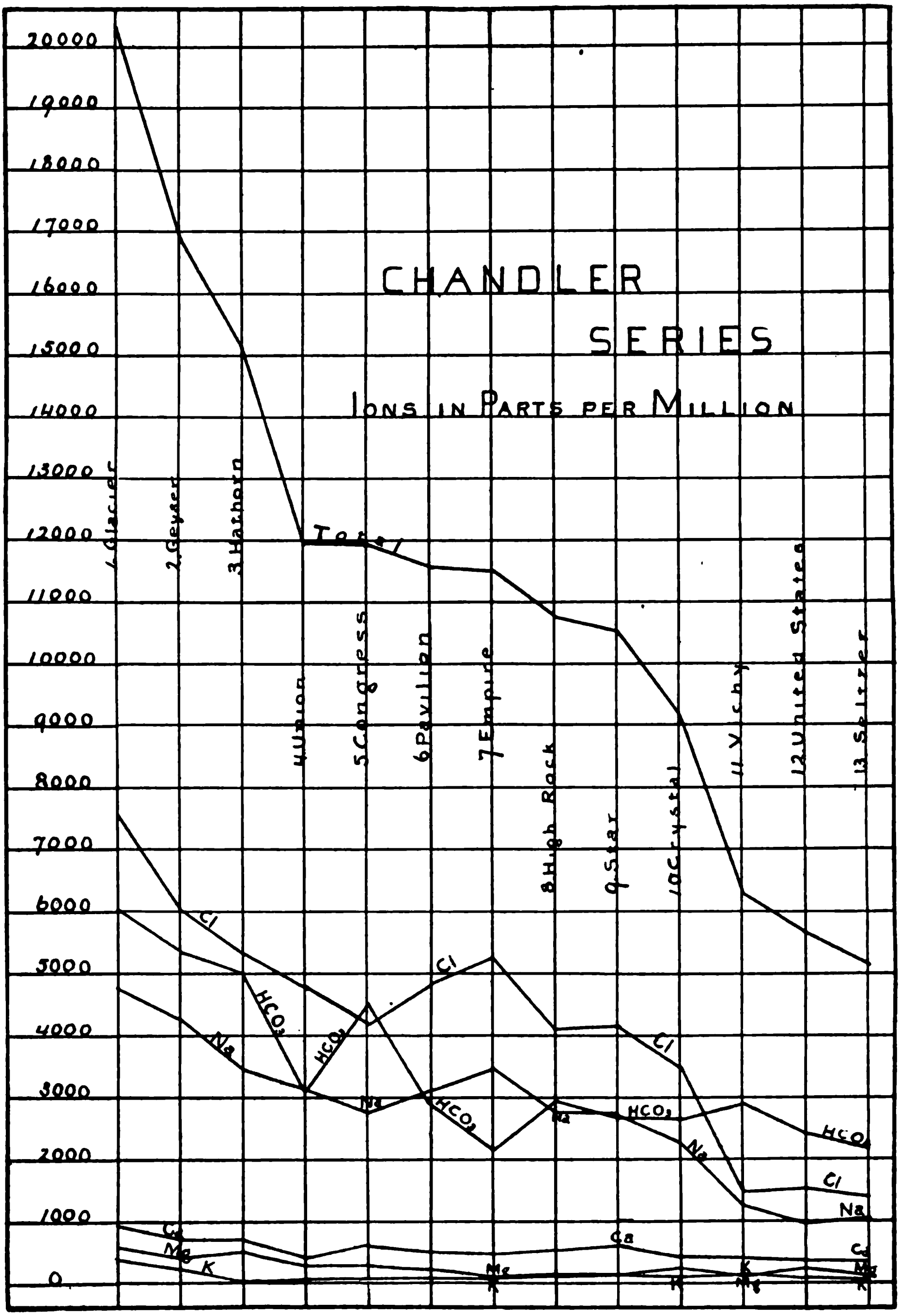

Figure 5 Diagrams of ions in parts per million

When statistics are prepared of these analyses, the following results become apparent. There are 66 analyses:

	Maximum	Minimum	General Range
$NaCl$	87.	21.2	45–60
$Ca(HCO_3)_2$	40.6	1.4	15–30
$Mg(HCO_3)_2$	27.9	2.3	5–20
$NaHCO_3$	67.3	.6	1–15
KCl	11.2	.4	1–5

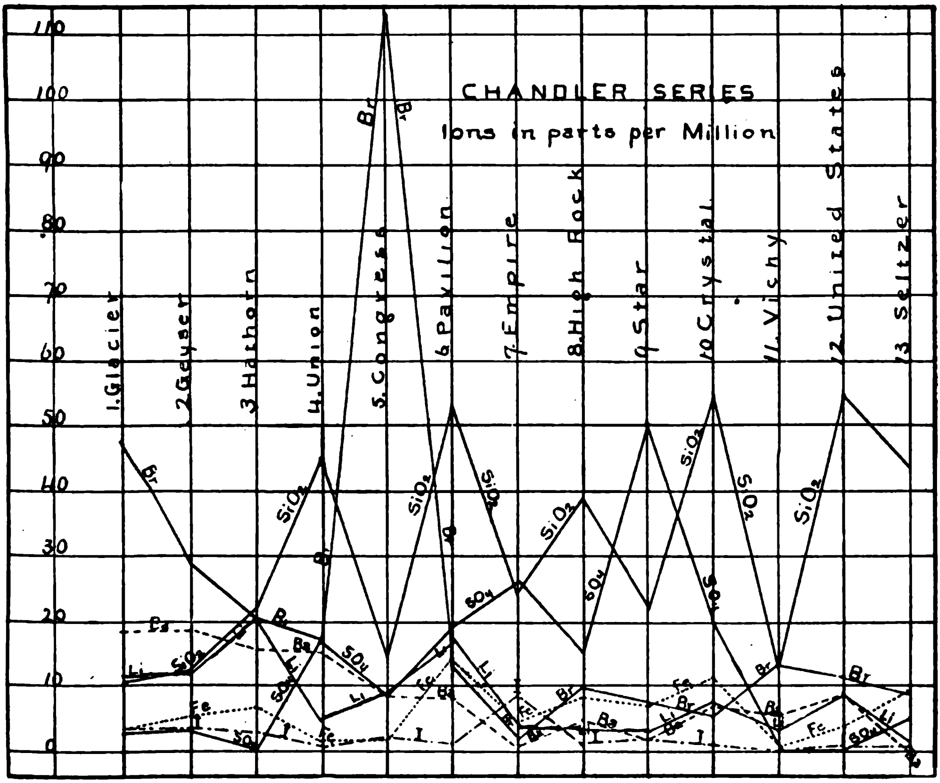

Figure 6 Diagrams of the rarer ions on an exaggerated scale as compared with figure 5

The extremely high values of NaCl are probably due to artificial strengthening. The minimum is due to the artificial addition of $NaHCO_3$, which relatively decreased the NaCl. NaCl above 60 per cent is an object of suspicion. The maximum, 40.6 of $Ca(HCO_3)_2$ is from a recent analysis of the High Rock. The next value is 40.4, of the Red spring. Then follow, 40.3 of the Magnetic and 38.6 of the Flat rock. All these have low total grains in the gallon, being respectively 129.4, 249.3, 214.7, and 253.8. All are from springs in

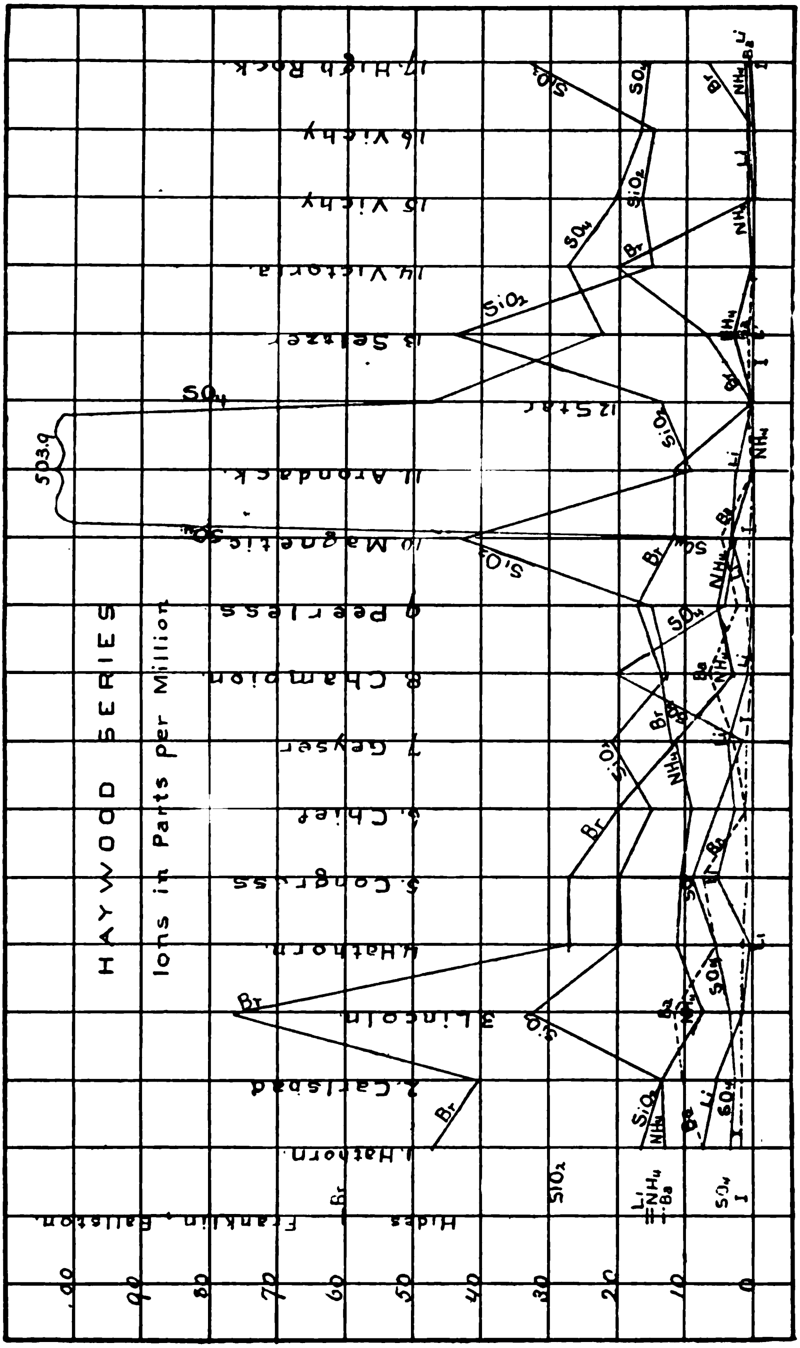

Figure 8 Diagrams of ions of the less abundant components, based on the analyses of J. K. Haywood and B. H. Smith 1905

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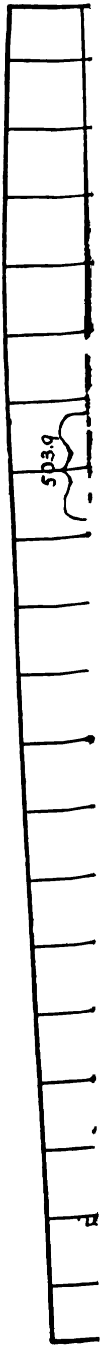
503.9

the northern part of the village. As the strength in salt and the total grains per gallon have diminished in later years, the relative amount of calcium bicarbonate has increased. This salt is always available for the carbonated waters to dissolve from the limestone. One would anticipate the same relation for the magnesium bicarbonate but in the high percentages of the table, it seems difficult to establish them. The magnesium salt is generally less than the lime, but in the six percentages of 20 and above, five exceed the lime salt, and one of the Congress' 1843, is almost equal.

In the values of $NaHCO_3$ above the superior limit of the general range, there are six, respectively: 22.4, 22.9, 25.2, 29.1, 33.0, and 67.3. All the other fifty-seven analyses (in three $NaHCO_3$ is not reported) run less than 15; forty-seven of them less than 10. The high values may be regarded in a questioning spirit.

In ten analyses no KCl is reported. Fifty-two others are less than 5. The three remaining are 6.8, 9.8 and 11.2.

These analyses are of interest when compared with those recorded for sea water on a subsequent page.

THE CARBON DIOXID

This gas is one of the most important features of the waters and is what gives them their palatable taste. Before undertaking its discussion a few fundamental properties of it may be recorded in order to make the subsequent statements intelligible. We have to distinguish between the uncombined (free) carbon dioxid and the portion combined with the bases as bicarbonates.

The combined portion remains in solution and is not apparent to general observation. The uncombined is also in solution in the depths of the earth, having formed with water, H_2O, carbonic acid, H_2CO_3, but as the water rises to the surface, this weak acid under the influence of diminishing pressures breaks up again into H_2O and CO_2. The gas escaping causes the effervescence or ebullition, as the case may be. Not all of it escapes because under the ordinary surface conditions the water retains in solution an amount of gas equivalent to its volume. That is, the water dissolves one volume of the gas. While the presence of the NaCl has some effect on the solubility of the CO_2, yet it is not enough seriously to influence the relations. The one volume of the gas which normally remains in solution can be driven off by boiling, or can be freed in a vacuum.

Ten cubic feet of CO_2, at ordinary temperatures and pressures, weigh practically one pound, so that one cubic foot is about .1 of a pound. If the specific gravity of air be taken as 1.0, CO_2 is 1.529. A liter of air weighs 1.293 grams, and a liter of CO_2 weighs 1.976. Gases are of course very sensitive to changes of temperature and pressure, and therefore in very accurate statements both have to be mentioned, but without going into too great refinements the above figures will answer for ordinary temperatures and pressures.

Since a gallon is 231 cubic inches, or .1337 of a cubic foot, a gallon of CO_2 weighs .01337 pounds or, as there are 7000 grains in a pound, about 93.6 grains. Where analyses are expressed in grains per gallon, and CO_2 is reported (as in the Chandler series) both as total CO_2, and as CO_2 in carbonates and bicarbonates, we can easily obtain the free gas by subtracting the latter from the former. If we then divide the free CO_2 expressed in grains by 93.6 we change it over to volumes. The necessary data are given in the Chandler series. In the analyses from the Department of Agriculture, the data are given in the thirteen analyses of samples taken directly at the springs. Since they are expressed in cubic centimeters per liter they read off directly in volumes, but it is obvious from the figures that they do not represent the total gas that reaches the surface with the waters.

The best guide to the amount of carbonic acid gas emerging with the mineral waters is furnished by the experience of the gas companies. The richest in gas was found to be the Adams well of the New York Company now the General Carbonic Company. It yielded five volumes of the gas leaving one volume in solution. The general average, however, was two or three.

THE WATER SEAL

Under the general topic of carbonic acid gas, note may be made of a very curious phenomenon connected with the natural flowing springs which have been drilled and cased. If even in the most gaseous one the top of the casing be covered tightly so as to prevent the escape of the water and gas, and if the tight cover be maintained in this condition long enough to permit all the free gas to rise and collect immediately beneath it so that the well becomes quiet, the well will not resume its flow on removing the obstruction. It must be artificially started with a pump. The phenomenon is called the *water seal,* since the spring is, as it were, sealed off by water.

The explanation lies in the following relationship of the solubility of carbonic acid gas to the pressure under which the water stands at time of solution. Thus, when the temperature is 55° F. under a pressure of one atmosphere water dissolves about one volume of carbonic acid gas. With a higher temperature it dissolves less, and with a falling temperature more. Under a pressure of five atmospheres it will dissolve at 55° F. about five volumes. Now an atmosphere is roughly 14 pounds pressure to the square inch, and is equivalent to a head of about 32 feet of water. In a standing column of water as soon as we pass a depth of 160 feet the overlying liquid will exert a pressure of 5 atmospheres and can keep 5 volumes of gas quietly in solution. As we go deeper more and more gas can be dissolved with the increasing pressure. The waters in the bored wells usually come from a depth of about twice 160, and are but half saturated with gas for that depth. All the gas is in solution just as it is in a siphon of carbonic water. If, however, we get an upward flow started, so that the dissolved gas under diminishing pressure can escape from solution, it replaces a part of the heavier water with the lighter gas, and greatly reduces the specific gravity of the water column, and therefore diminishes the pressure resting on its base. The solubility is reduced, more gas escapes and a flow of gas and water results. When a barrier is interposed the free gas escapes and collects at the top. Equilibrium of solution and pressure is established and the water stands quietly in the tube. Nevertheless it seems surprising, when one views the agitated spouting and gurgling of the springs, to think that they can be brought to rest by so simple a means.

It also follows that when carbonic acid gas is once in solution and at depths where the pressure prevents saturation and escape, the gas will remain in solution indefinitely. It is no more remarkable that this carbonated solution should be contained in the strata of the earth for one or several geological periods, than that a solution of common salt or of any other salt should do the same.

The Saratoga and Ballston springs are, on the whole, the richest in carbonic acid of those known in this country.

THE TEMPERATURE OF THE WATERS

The waters come to the surface with temperatures that are in almost all cases between 50° and 54° F. or 10°–12° C. Doctor Chandler records in a total of eight cases six between 50 and 52, and two at 48 and 46. For the Ballston waters he gives two at 52 and one at 54. Many readings at the wells of the General Carbonic Co. fall in with the first general statement of 50° to 54° F. The prevailing temperature is somewhat above the mean annual temperature for Saratoga Springs.

The temperatures are appreciably higher in the summer than in the colder season, undoubtedly from the effect of the admixture of surface waters which vary with the months of the year. Mr J. C. Minor, jr, has made the following observations upon the wells of the former New York Co., now the General Carbonic Company. All but the last two were pumped wells.

	April 24, 1909	June 7, 1909	August 15, 1909
Old Hurlbut Well	51.2 F.	52.3 F.	53.2 F.
No. 1 Well	50.3	51.8	56.8
[1] Hathorn No. 1	51.4	52.9	53.8
[1] Hathorn No. 2	51.0	52.5	53.6
Bridge	50.3	50.8	53.0
Hayes	51.2	52.1	53.2
Adams	48.2	49.8	50.5
[2]Carlsbad		50.7	51.4

THE SPECIFIC GRAVITY OF THE WATERS

Doctor Chandler records the specific gravity of nine of the Saratoga springs; they vary with the amount of dissolved solids ranging from a minimum of 1.0034 to a maximum of 1.012.[3] The Ballston waters which are specially rich in dissolved salts, range from 1.0125 to 1.0159.

CLASSIFICATION[4]

Mineral waters are necessarily classified upon the basis of their chemical composition. A grouping especially favored in America is the following. A thermal spring, as defined by A. C. Peale, is one whose temperature exceeds 70° F. The scheme below is Haywood's modification of Peale's original proposal:

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[1] These wells called Hathorn No. 1 and No. 2 are not to be confounded with the well-known spring in the village nor with the new flowing springs south of Geysers Station. The names are purely of local application.

[2] Now the Caesa.

[3] There is an obvious misprint in the tabulated analysis of 1.096 for 1.0096 under the Congress Water. Amer. Chemist, Dec. 1871, p. 203. It is repeated in Cairn's Quant. Analysis.

[4] This subject is well treated by A. C. Peale in "Mineral Waters of the United States," U. S. Geol. Survey, 14th Ann. Rep't.

With minor subdivisions much the same is also used by J. K. Haywood, in Bulletin 91, U. S. Dept. of Agriculture, from which the analyses have been taken and so often commented upon above. Peale's classification is based on recast salts, Haywood's on ions.

GROUP	CLASS	SUBCLASS	FURTHER DESCRIPTION	FURTHER DESCRIPTION
Thermal and Nonthermal	1 Alkaline	Carbonated or bicarbonated Borated Silicated	Iodic Lithic Potassic Calcic Magnesic Ferruginous	Nongaseous Carbon-dioxated Sulfuretted Azotized Carburetted Oxygenated
	2 Alkaline-saline	Sulphated Muriated Nitrated		
	3 Saline	Sulphated Muriated Nitrated	Aluminic Arsenic Bromic Iodic Silicious Boric	
	4 Acid	Sulphated Muriated		

1 Alkaline waters are those which give an alkaline reaction and contain carbonic, bicarbonic, boric or silicic acid ions in predominating quantity among the acids.

2 Alkaline-saline waters constitute an intermediate group between 1 and 3. They yield an alkaline reaction. Either with or without the acid ions mentioned under 1, they have in predominance, sulfuric, muriatic or nitric ions.

3 Saline waters are those which have an alkaline or neutral reaction and contain sulfuric, muriatic or nitric acid ions in predominating quantity.

4 Acid waters yield an acid reaction and contain either sulfuric or muriatic ions in predominance.

In descriptions Mr Haywood suggests that the terms in the table beginning with those headed "class" be used so that the columns with slight modifications come in the following order: 1, 4 through aluminic, 3, 2, 4 from arsenic to the close, 5. The Hathorn spring Mr Haywood describes as a nonthermal, sodic, muriatic, alkaline-saline (lithic, bromic, iodic) carbon-dioxated water. Other springs at Saratoga vary somewhat from this description. In those with high calcium, we might have to introduce calcic after sodic; perhaps also magnesic. Not every water has enough lithium, bromin or iodin to justify the terms lithic, bromic, or iodic. In a few sodium chlorid is in such marked predominance as to throw them into the saline class. The questionable analysis of the Geyser water with its extraordinary sodium bicarbonate, would come under the first class of alkaline waters. We are safe in saying, however, that the Saratoga waters belong under the alkaline-saline, rarely the saline classes. That they are all muriated and sodic. Some are calcic and magnesic, one or both. Some are lithic, bromic, iodic, one or several. Practically all of importance are carbondioxated.

VARIATIONS IN THE WATERS

In the course of the last seventy-five years there have been variations in the waters as shown by the analyses and by the experience of owners of springs. Even if we allow for differences in the accuracy of chemical methods, and of chemists themselves, throughout this long stretch, a solid substratum of sound inference remains. Several instances will be of interest, but it is not only important but necessary to understand the possible modifying factors.

In the early years of settlement and utilization all the springs issued from natural crevices in the rock, possibly, as in the case of the High Rock, coming to the actual surface through gravel, bog, calcareous tufa, etc. In order to protect and maintain the flow it soon became customary to sink a pit through the overlying loose materials to the bedrock, and cement tightly to the rock around the actual vent, a pyramidal or conical wooden tube, prolonged in a pipe, within which the mineral water reached the surface, undiluted by admixtures of surface waters, so far as these stood in the gravels etc.

As time went by wells were drilled into the rock, either to restore old and dying springs or else to develop new ones of which there might be no surface indications. If successful these bore holes would strike a productive crevice. If they were continued below it, without additional supplies, the hole might later be plugged below the productive point. Above the productive crevice, the hole would be cased by a larger pipe, fitted tightly into the bore hole with a gasket at its lower end. A smaller pipe having been introduced within the casing, it also had a gasket above the supply point. The waters thus rose in the inner pipe. The casing kept out the higher and of course weak ground waters, and maintained the strength of the deep-seated mineral spring. If, however, the casing should rust through as was the experience in seven years' service of one pipe in a well on the property of the New York Carbonic Gas Co., this protection would no longer be afforded and weakening of the waters might follow. There are also some unsuccessful holes in which casings may or may not be left, and down which surface waters are tapped by a relatively large inlet to the productive horizons. In one case, that of the Ainsworth well, a charge of explosive was set off several hundred feet beneath the surface and of course it shattered the surrounding rock, in a way which might give greater ingress to mineral waters, but might also give the weak surface waters a more favorable entrance.

Where active pumping is carried on, as has been the case on the properties of the gas companies, the ordinary level of the ground water is lowered near the pump or pumps and its surface forms an inverted cone, or approximation to a cone, called the cone of depression. The diameter of its base, or the radius of influence of the pump, can be determined by observation if there are wells all about. This matter was carefully studied on the property of the General Carbonic Co., and it was found that the remotest depression of the ground water observed was less than 400 feet from the pumps. The influence was irregular, some wells even quite near each other showed slight sympathy.

Where the wells have been drilled through slate in order to tap the productive limestone it is important to keep the casing tight because the slates furnish a water containing sulfur compounds, more particularly sulfuretted hydrogen, which even in small quantities gives an undesirable taste to the water. The inlet of surface waters from the slates is thus not only weakening to the spring but a detriment in other respects.

In the history of a water and in comparisons, it is unavoidable that samples should sometimes be taken from different vents on the same property. Thus, when older springs have given out, or perhaps have been obstructed with sediment, or have found other natural vents, new bore holes have been put down. But they are so near the old spring, as a rule, as to give presumptive evidence of tapping at least much the same underground source.

Parts per million

	J. H. Steel Before 1838	J. R. Chilton 1843	J. F. Dana ?	C. F. Chandler 1871	J. K. Haywood 1903–05
1 Congress spring					
Total	11197.9	11215.4	12324.3	11915.3	10232.7
NaCl	6545.0	6185.1	7384.8	6806.8	5141.6
$Ca(HCO_3)_2$	2701.3	2371.5	3966.1[a]	2437.8	2276.5
$Mg(HCO_3)_2$	1628.6	2325.6	544.0	2069.9	1674.9

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[a] Undoubtedly the separation of calcium and magnesium was incomplete, some magnesium being weighed as calcium.

	J. H. Steel Before 1838	J. R. Chilton 1840	E. Emmons 1839	C. F. Chandler 1871		J. K. Haywood 1903–05
2 High Rock spring						
Total	6604.5			10718.5		2347.2
NaCl	3214.7			6631.7		738.2
$Ca(HCO_3)_2$	1907.4			2239.6		906.8
$Mg(HCO_3)_2$	1047.2			933.6		364.9
4 Star spring						
Total			6244.1	10495.1		2958.0
MaCl			3179.0	6772.1		2150.5
$Ca(HCO_3)_2$			71.4	2115.8		481.9
$Mg(HCO_3)_2$			2218.5	1052.4		130.8
3 Pavilion						
Total		6613.7		11583.5		
NaCl		3190.9		7818.3		
$Ca(HCO_3)_2$		1455.2		2042.9		
$Mg(HCO_3)_2$		168.3		1304.4		
2 Geyser						
Total				16856.3		7656.0[a]
NaCl				9555.7		1588.8
$Ca(HCO_3)_2$				2896.8		471.4
$Mg(HCO_3)_2$				2538.8		364.9
3 Hathorn						
Total				15102.8	13170.0	10859.0
NaCl				8668.3	7343.7	5762.4
$Ca(HCO_3)_2$				2901.0	3098.3	2635.3
$Mg(HCO_3)_2$				2999.8	1974.7	1377.8

	C. F. Chandler 1869		J. K. Haywood 1903–05
5 Seltzer			
Total	5134.2		2737.0
NaCl	2283.1		1111.0
$Ca(HCO_3)_2$	1527.8		1000.0
$Mg(HCO_3)_2$	685.8		405.6
6 Vichy	1872		
Total	6244.5	2629.1[b]	2441.0[b]
NaCl	2187.9	1499.1	1459.5
$Ca(HCO_3)_2$	1623.8	158.8	167.3
$Mg(HCO_3)_2$	705.5	60.8	58.8

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[a] This is the analysis with 5058.3 $NaHCO_3$.

[b] These two analyses have respectively 837.1 and 693.1 $NaHCO_3$.

4 Kissingen, now the Arondack	Sharples 1872	J. K. Haywood 1903–05
Total	10958.7	3094.0
NaCl	5754.5	1725.1
$Ca(HCO_3)_2$	2384.4	104.1
$Mg(HCO_3)_2$	1198.0	236.2

1 Champion	C. F. Chandler[a] 1871	
Total	20324.9	6790.2
NaCl	11938.1	4521.6
$Ca(HCO_3)_2$	3860.2	1410.6
$Mg(HCO_3)_2$	3286.5	488.3

Ballston Spa

Franklin Artesian well (now Hide's Franklin spring)	C. F. Chandler 1869	Dep't of Agriculture Later than 1905
Total	20134.8	20542.6
NaCl	11208.8	11186.7
$Ca(HCO_3)_2$	3439.6	4007.2
$Mg(HCO_3)_2$	3023.7	2822.0

Study of these data brings out the following conclusions. The Congress spring shows no appreciable change from 1840 to 1870. From 1870 to 1903 it fell off about one-sixth or 12 to 13 per cent. The High Rock increased in strength from 1840 to 1870, presumably because of the prevention of inflowing surface water. It then fell off from 1870 to 1902 nearly 80 per cent in dissolved solids, most of all in NaCl. The Pavilion spring greatly increased in strength from 1840 to 1870, probably from improved protection against surface waters. The Star spring improved from 1839 to 1870, but then fell off from 1871 to 1903 over 70 per cent in strength. The Champion spring (discovered 1871) decreased from 1871 to 1903 about 70 per cent in strength. The Geyser spring from 1870 to 1903 fell off about 55 per cent. The Hathorn (discovered 1868) decreased from 1870 to 1903 about one-third in strength. The Kissingen or Arondack, as now called (discovered 1872), declined from 1872 to 1903 about 70 per cent. The Seltzer (discovered in 1865) from 1869 to 1903 fell off somewhat less than 50 per cent and finally the Vichy (discovered 1872) declined about 60 per cent.

The general conclusion from the concurrent testimony of these comparisons is that the mineral waters, especially in Saratoga Springs village, have greatly declined in strength in the last thirty years.

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[a] Quoted by A. C. Peale, Bul. 32, U. S. Geol. Surv. p. 38.

By way of contrast two analyses are given of the Franklin Artesian water of Ballston Spa (discovered 1867), one made in 1869 and the other at least 35 years later in the Department of Agriculture, Washington. There is no appreciable change. The water comes from much greater depth than the Saratoga wells and far fewer wells have been drilled in Ballston.

THE ORIGIN OF THE MINERAL WATERS

The previous pages place before a reader the geological and chemical facts about the springs upon which, aided by experience gained elsewhere, the scientific explanations of their origin must be based. This interesting question did not fail to attract the attention of early observers. Dr J. H. Steel, to whom we owe so much of valuable record, was alive to the difficulties of the problem. On page 202 of the second edition (1838) of his book which was first published in 1817, he states in closing: "Much interest has been excited on the subject of the source of these singular and interesting waters, but no researches have as yet satisfactorily unfolded the mystery. The large proportion of common salt found among their constituent properties may be accounted for without much difficulty, all the salt springs of Europe as well as those of America being found in geological situations exactly corresponding to these,[1] but the production of the unexampled quantity of carbonic acid gas, and the medium through which the other articles are principally retained in solution, is yet and probably will remain a subject of mere speculation. The low and regular temperature of the water seems to forbid the idea that it is the effect of subterranean heat, as many have supposed, and the total absence of any *mineral acid* excepting the marine[2] which is combined with soda, does away with the possibility of its being the effect of any combination of that kind. Its production is therefore truly unaccountable."

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[1] Our more complete geological knowledge today would hardly justify us in admitting this sweeping statement.

[2] There are now known small amounts of sulfuric and nitric, but in the large way Doctor Steel's statement is true. It is reported that Doctor Steel was instrumental in organizing a company (in the decade of the twenties) to bore for salt deposits on the evidence of the springs, but that after drilling 110 feet the enterprise was abandoned.

Both W. W. Mather and L. C. Beck in their respective final State geological reports in 1842, discuss the springs but neither of them connects them with the fault which became later the object of much respect. In fact, while the cliff of limestone east of the springs is mentioned by Professor Mather in describing the valley in which the springs are found, he does not interpret it as a fault. On page 94 of the Report on the First District, Mather speaks as follows:

> The Saratoga Springs are supposed to derive their mineral qualities from the limestone and slate beds that underlie the town, or they may be more deeply seated; but the water is usually obtained from beneath the clay and "hardpan" beds that overlie the rock. Limestone rock that belongs to the calciferous group, crops out in the village and in many places in the vicinity, and the primary rocks are not far distant on the north and west.

Regarding Ballston, he expresses himself as follows, on page 98: "It is probable that the mineral qualities of the water originate at the contact of the fucoidal slate with the underlying Trenton limestone, which is probably not more than fifty feet below the level of the valley at the springs." He then cautiously advises boring at some low point until the limestone is struck and that the hole be continued even to the calciferous sandrock. "At Saratoga the course of the water is supposed to be in the limestone, and this limestone which is the lower portion of the Mohawk, or upper part of the calciferous sandstone, must lie at a depth of one hundred and fifty feet at Ballston. Borings, however, might entirely miss a seam productive of water." It is interesting to note that the wells which have been bored go down through about four times as much slate as was anticipated.

Doctor Beck in his valuable report on the mineralogy of the State, discusses the chemistry of the waters at some length and gives several of the analyses which have been used on an earlier page of this paper. On page 137, after speaking of the discharge of gas at Saratoga and at Ballston, sometimes explosively at the latter, he states: "From these facts, it is evident that here, as at Saratoga, there are certain agencies in operation which cause an abundant evolution of carbonic acid, a part of which has been originally held in solution by the water but another and perhaps much the largest part is an independent stream of gas, discharged in the form of a solfatara, or gaseous spring. That this gas originates at great depths and rises freely through the crevices in the rock, is rendered probable from its alternately breaking and disappearing at points somewhat distant from each other. And perhaps the opinion of

Berthier may here be applied, viz, that the water of the spring is forced up by the elasticity of the confined gas. . . . In general, the occurrence of carbonic acid in these waters is to be ascribed to the existence of large quantities of it held in solution by water at great depths, and therefore under enormous pressure; or by the gas itself being kept by the same agency in a liquid form, until, by the removal of the pressure, it assumes the gaseous state, and is thus disengaged." These phenomena have been discussed in the light of modern chemistry and physics under the topic Water Seal, on page 40. At some date between 1842 and 1871, when Professor Chandler published the paper, to be shortly reviewed, the fault was recognized and was regarded as of importance in connection with the springs.

In the years just before and after 1860, Dr T. Sterry Hunt, chemist of the Geological Survey of Canada, published a number of papers dealing with the chemical side of geology and among them one of much importance in connection with mineral waters.[1] The paper has had a decided influence upon some of the current views regarding the Saratoga Springs, although Doctor Hunt refers to the springs only in a general way. Doctor Hunt's attention had been drawn to many waters which issue from the lower Paleozoic strata of Quebec and Ontario. He viewed these waters as representing the ancient Paleozoic sea in which the sediments had been deposited; that is, he believed them to be "connate" as the term has been explained on page 19. In a still earlier contribution read before the Geological Society of London,[2] Doctor Hunt states "When we examine the waters charged with saline matters which impregnate the great mass of calcareous strata constituting in Canada the base of the Paleozoic series, we find that only about one-half of the chlorine is combined with sodium; the remainder exists as chlorids of calcium and magnesium, the former predominating, while sulphates are present only in small amount. If now we compare this composition, which may be regarded as representing that of the Paleozoic sea, with that of the modern ocean, we find that the chlorid of calcium has been in great part replaced by common salt, a process involving the intervention of carbonate of soda and the formation of carbonate of lime. The amount of magnesia in the sea, although diminished by the formation of dolomite and magnesite, is now many times greater than that of the lime; for as long as chlorid of calcium remains in the water, the magnesium salts are not precipitated by carbonate of soda."

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[1] The Chemistry of Natural Waters. Amer. Jour. Sci. March, July, and September 1865. Reprinted with some omissions in Chemical and Geological Essays, 2d ed. p. 93–167, 1878.

[2] On some points in chemical geology, Quar. Jour. Geol. Soc. Nov. 1859. Chemical and Geological Essays, 2d ed. p. 10, 1878.

Doctor Hunt believed that the bicarbonate of soda which entered the sea in river waters and which resulted from the decomposition of the soda-feldspars was the agent which had brought about this change in the long stretch of geological time since the early Paleozoic. Obviously, if Doctor Hunt's views are correct about the presence of calcium and magnesium chlorids in large proportions in the early Paleozoic sea water the Saratoga Springs are not derived from this ancient connate water, since calcium and magnesium chlorids fail.

On January 20, 1871, Professor Charles F. Chandler delivered a lecture on "Water" before the American Institute, at the Academy of Music, New York City. The lecture was published in December of the same year in the American Chemist, a monthly journal of chemistry, then in its second volume. The paper is an extremely valuable contribution and made public nearly all the analyses used in the "Chandler Series" of the preceding pages. Speaking of the origin of the springs, on pages 202 and 204, Doctor Chandler expresses himself as follows:

> The Laurentian rocks consisting of highly crystalline gneiss, granite and syenite, are almost impervious, while the overlying Potsdam sandstone is very porous and capable of holding large quantities of water. In this rock the mineral springs of Saratoga probably have their origin. The surface waters of the Laurentian hills, flowing down over the exposed edges of the Potsdam beds, penetrate the porous sandstones, become saturated with mineral matter, partly derived, perhaps, from the limestones above, and are forced to the surface at a lower level by hydrostatic pressure. The valley in which the springs all occur indicates the line of a fault or fracture in the rocky crust, the strata on the west side of which are hundreds of feet above the corresponding strata on the east.
>
> The mineral waters probably underlie the southern half of the entire county, many hundred feet below the surface; the accident of the fault determining their appearance as springs in the valley of Saratoga Springs, where by virtue of the greater elevation of their distant source they reach the surface through crevices in the rocks produced by the fracture.
>
> Their common origin is also shown by analysis. All the springs contain the same constituents in essentially the same order of abundance, they differ in the degree of concentration merely. Those from the deepest strata are the most concentrated. . . .

Then follow mention of the common dissolved substances and instances of the deep artificial borings which are believed to penetrate the Potsdam sandstone and which bring up waters much stronger than the natural springs. Doctor Chandler concludes this topic by saying: "Down in the rocky reservoir the water is charged with gases under great pressure. As the water is forced to the surface the pressure diminishes, and a portion of gas escapes with effervescence. The wells deliver, therefore, enormous volumes of gas with the water, a perfect suds of water, carbonic acid and carburetted hydrogen."

The above is a very clear and interesting statement of the views prevailing at the time regarding the waters. The important point of the source of the carbonic acid gas is not taken up, as perhaps could hardly be expected in a popular lecture, but even granting the suggested origin of the dissolved mineral matter from ancient sea water, there remains the very important matter of the gas which finds no explanation. More detailed geological study has furthermore reduced the throw of the fault in Saratoga Springs to about 50 feet and the water so far as we know in the springs under discussion all enters the bored wells from the Little Falls dolomite, or as it was called at the time Doctor Chandler wrote, the Calciferous sandrock, and later on the Beekmantown. The great depth of some of the boreholes is due to the thickness of overlying slate. The deep Hathorn drilled well did indeed at a depth of 1006 feet end well within the Potsdam sandstone, but the water coming from this source is stated to have been much weaker than that derived higher up, presumably from the Little Falls dolomite. The lower waters were plugged off, and so far as the writer is aware, they present the only case known to us of waters actually coming from the Potsdam in the region of Saratoga.

In September 1880, the American Pharmaceutical Association met in Saratoga Springs. One of its members, Mr Charles F. Fish, prepared an interesting sketch of the springs which, after presentation, was printed in volume 28 of the Association's transactions. On page 488 we find the following:

> One explanation is that the water falls on the western height of land and percolates downward artesian fashion, dissolving and carrying with it the various substances of which the rocks are composed. These are decomposed by their reaction on each other, forming new compounds with the evolution of CO_2, which is dissolved by the water, highly impregnating it, and increasing its solvent power. Reaching the fault, the waters rise.

The mineral matter resembles sea water and is supposed to be derived from ancient oceans.

Others, supporters of a second view, derive the waters as before, but reject the derivation of the waters' dissolved burden from the rocks. They think it reaches the fault relatively pure and then is charged with mineral and gaseous constituents, which have come up through the fault from the internal fires of the earth. The substances are those customarily given off by volcanoes.

In a valuable "History of Saratoga County" by Nathaniel Bartlett Sylvester, Esq., of the local bar, published in 1893, will be found on page 32, the following outline which summarizes very well the views held by many at this date regarding the springs:

> The principal mineral springs of Saratoga county occur mostly in the villages of Saratoga Springs and Ballston Spa. The village of Saratoga Springs, where the greater number of the springs occur, is built directly over and extends for its whole length along on both sides of the dividing lines between the two great mountain systems above described, the Laurentian-Adirondack to the north and west, and the Appalachian to the east and south.
>
> This dividing line between the two mountain systems, over and along which the village is built, is there characterized by a deep fissure or rift in the underlying strata, known to science as a fault. The fault was doubtless caused by the deep subsidence of the Appalachian strata along the division line, consequent upon the mighty upheaval to the eastward, when the mountains arose from the Silurian sea. This profound subsidence of the Appalachian strata along the division line sank the bottom waters of the Silurian sea, which covered the land with all of its accumulated marine riches, into a vast abyss which now underlies the village to the eastward of the rock fissure. Out of this reservoir of old marine treasures, the gases there engendered still force the waters, which bring these marine riches with them, up through the deep fissures in the rifted rocks into the light of day, thus forming the natural mineral springs of Saratoga, which rise to the earth's surface in Saratoga county.

Again, on page 160, the same view is repeated in briefer statement. Judge Sylvester's description in its quaint and precise legal phraseology makes clear the widespread view of recent years that the Silurian sea water had saturated the rocks and that it had remained in them ever since so as to now furnish the mineral waters. We are forced to modify our unqualified acceptance by recalling Dr T. S. Hunt's conclusion that these ancient waters had a radically different composition from that of the springs (see above, pages 50, 51). One can not but raise the question also, whether, inasmuch as the area has apparently been land, it may be, ever since Paleozoic time, the ancient sea waters could well have been preserved throughout so long an interval. The fault, too, while a very long one, has only the slight disturbance of about 50 feet in Saratoga Springs.

If we are impressed with the possibilities of sea water in the rocks, and at first glance the generalities of composition suggest them, we may query if the ancient seas are the only source. The springs suggest rather the modern sea, with its high sodium chlorid, than the ancient ones with high magnesium chlorid, as described by Dr Sterry Hunt. Has the sea of fairly recent geological time ever covered the region of Saratoga?

We know from the rapidly growing number of buried river channels that the closing Tertiary period was a time of relative elevation in the northeast. The bedrock on which the water once flowed is now far below the present surface. The Glacial epoch apparently opened with elevated conditions but closed with a great depression of the land. Lake Champlain was certainly connected with the sea, as was shown by the skeleton of a whale, dug out of a sand bank in the town of Charlotte, Vt., when the Rutland and Burlington Railroad was under construction. The railroad runs through Charlotte at about 200 feet above tide, so that the sea water must have stood above this level. The present divide between Wood creek, the southern inlet of Lake Champlain, and the feeders of the Hudson near Dunham Basin, is a little over 160 feet. The postglacial sea might so far as we can see have crossed from Lake Champlain to the Hudson, but whether it stood as high as the 300 or 320 feet contours on which the springs emerge is not demonstrated, although not improbable. If the sea had stood above these strata, they being presumably filled with earlier fresh ground water, we may wonder if it could have found a way to fill their interstices, and drive out the fresh water. Sea water is heavier than fresh, and having access to the underground reservoirs of fresh water would probably have at least diffused itself through them. We may therefore admit that possibly an arm of the Atlantic stood in postglacial times above the present sites of the springs.

But the hypothesis of the sea water deserves very earnest attention. Our only safe ground is to run some careful comparisons between the mineral springs and the modern sea water, with perhaps some further reservations regarding possible differences between the oceans of today and those of the past.

Analyses of sea water have been prepared in the greatest abundance. Samples have been taken not alone from the ocean, but also from estuaries and arms which may be only brackish. Analyses are sometimes published of the water and its dissolved salts and sometimes of only the evaporated residue. Results in the latter case may be expressed either in the form of salts or in that of elements and ions. Taking a collective statement of results from F. W. Clarke's "Data of Geochemistry," Bulletin 330 of the United States Geological Survey, we find on page 23, that the general salinity of the ocean is about 3.5 per cent or 35,000 parts in a million, whereas our strongest Saratoga or Ballston waters fail to reach 2 per cent or 20,000 parts in a million, when we express the dissolved mineral matter as normal carbonates instead of bicarbonates. We may perhaps assume the admixture of surface waters as conceivably reducing the strength of the latter when compared with the former, or we may assume estuarine sea water, like that of the Baltic which is dilute. An average range for Saratoga Springs waters in former years was about 1 per cent or 10,000 parts in a million (see above, page 34) and from the most recent analyses we learn that a notable number lie between .2 and .3 per cent, or 2300 to 3100 parts per million. The latter values imply still greater admixtures of meteoric ground waters.

If the salts of the ocean are analyzed after evaporation to dryness, they yield a general composition as given by Dr F. W. Clarke (page 23) of

$NaCl$	77.76
$MgCl_2$	10.88
$MgSO_4$	4.74
$CaSO_4$	3.60
K_2SO_4	2.46
$MgBr_2$	.22
$CaCO_3$	.34
	100.00

Considered as elements no others would reach more than 0.001 per cent and are therefore negligible.

These results are obviously very different from the Saratoga and Ballston waters, in which, as has been shown on the previous pages, while we have NaCl as the chief ingredient, we yet have no $MgCl_2$, and almost no sulphates. The sea salts, on the contrary contain 10.80 per cent of the last named. In the oldest series of analyses of Saratoga waters (see above, page 24), the richest percentage in sulphates was .0028 and the poorest .0011. In the Chandler series the richest was 0.0091 and the poorest a trace. In the Department of Agriculture series the richest was 0.04449 per cent and the poorest 0.00021 per cent. Stated in this way, there is a very obvious and important difference between the mineral waters and the sea waters.

But we may run comparisons in another way: Dr F. W. Clarke summarizes upon page 95 of his invaluable work 264 analyses from eighteen different localities, whose salinity varies from a maximum of 5.854 per cent in the Red sea, to a minimum of 0.7215 per cent in the Baltic, where, as the writer has personally observed, both people and animals freely drink the water. When expressed as elements and ions there is extraordinary uniformity in the dissolved salts of the sea despite the widely varying salinity:

	MAXIMUM	MINIMUM	RANGE
Cl	55.96	54.62	1.34
Br	.19	.13	.06
SO_4	8.01	7.47	.54
CO_3	.46	.01	.45
Na	31.21	30.20	1.01
K	2.10	.64	1.46
Rb	.04	.03	.01
Ca	1.67	.89	.78
Mg	3.896	3.36	.536
Fe, SiO_2, PO_4, NH_4, NO_3, Al_2O_3, (Fe_2O_3)	.08	.02	.06

The last mentioned ingredients which are collectively grouped are only determined in a few instances. The same is true of rubidium (Rb). The greatest variability is shown by CO_3 and the next by potassium (K), but their amounts are relatively small. Calcium (Ca) also varies widely, but it also is small in amount. The most important ingredients, taken in order of abundance, chlorin (Cl), sodium (Na), the sulfuric acid ion (SO_4), and magnesium (Mg), change but slightly in this wide range of conditions.

When we come to compare the analyses of the Saratoga and Ballston waters with the above, certain allowances must be made. The mineral waters are heavily charged with carbonic acid which gives them greatly increased dissolving power upon limestone. We would expect the calcium and perhaps also the magnesium to be much in excess of the percentage in sea water. In making comparisons we would be justified in tentatively assigning the excess of calcium and of carbon dioxid over the figures of sea water to contributions provided in this way, and then recasting the remainder. We must also deal with analyses that are based upon *bona fide* natural waters. I therefore select a few chiefly from the series of

Dr Charles F. Chandler, adding to them several of later date, in which I have confidence. It has been necessary to reduce grains per gallon, or parts per million, to percentages of evaporated residue. Water must therefore be thrown out, and as compared with analyses previously discussed bicarbonates become normal carbonates.

Normal calcium carbonate in pure water (that is, containing no free carbonic acid) is stated by F. W. Clarke on the authority of T. Schloesing, to be soluble at 16° C. to the extent of 13 parts in a million (U. S. Geol. Surv. Bul. 330, p. 99, 1908). Calcium bicarbonate, that is, calcium carbonate in water with enough free carbonic acid to yield the bicarbonate, is soluble 385 parts in a million at 15° C. (Idem, page 99). Excess of carbonic acid increases the solubility as is shown by the values just cited for the Saratoga waters, which are about ten times that just given for $Ca\ (HCO_3)_2$ in pure water. On the other hand, sea water is not so good a solvent as pure water, and the Saratoga waters, in so far as they are brines, probably are also less favorable solvents than are pure waters.

Magnesium carbonate is stated by J. Roth (Allgem. and Chem. Geologie, I, 50. 1879), to be somewhat more soluble in carbonated waters than is calcium carbonate. The presence of calcium carbonate doubtless exercised some influence since in the Saratoga waters, just as Professor Roth states for waters in general, it is exceptional to find more magnesium carbonate than calcium carbonate.

	FRANKLIN, BALLSTON	HATHORN, SARATOGA	CONGRESS, SARATOGA	SELTZER, SARATOGA	HATHORN NO. 2, GEYSERS	GURN, WILTON
Cl	42.00	42.40	42.00	34.40	41.20	28.10
Br	.36	.16	1.10	.20	.10	.16
SO_4	.04	tr.	.09	.13	.04	....
CO_3	15.00	18.50	17.50	25.75	17.00	25.30
Na	28.8	27.30	27.60	25.50	30.80	26.00
K	2.0	.70	.80	.40	.48	2.33
Ca	5.0	5.70	6.00	9.30	6.22	11.20
Mg	5.0	4.00	3.40	2.80	3.07	3.40
Rest	1.80	1.24	1.51	1.60	1.09	3.51
	100.00	100.00	100.00	100.00	100.00	100.00

Of these analyses the first four are by Doctor Chandler. The fifth is of the recently bored well two miles south of Saratoga Springs and the analysis was made in the laboratory of the State Department of Health in 1911. The sixth is from the Lederle Laboratories, New York, and was made in 1910. It illustrates the most northerly of the present active springs, since the Gurn is eight miles from Saratoga Springs. The analysis brings out the tendency of the waters to the north to be richer in calcium, which in turn calls for more CO_3 and reduces the chlorin and sodium. The same effect is shown in the Seltzer water.

If in the above analyses we arbitrarily reduce the calcium to 1.67 as given in the sea water richest in this element, and the CO_3 to .46, as given in the sea water richest in this ion, thereby necessarily assuming the existence of calcium chlorid which no one has hitherto recalculated for the Saratoga waters, we can get a line on the ratio of sodium, chlorin, and magnesium. All this is done on the assumption that the high calcium is obtained from the limestone. Some magnesium is also undoubtedly obtained from the magnesium limestone, but the difference between the mineral waters and the sea water is not so great. In the recasting I have used the nearest round numbers. Thus, the analyses of the mineral waters have their several percentages respectively increased by dividing by approximately the following residual percentages: 82, 72, 79, 66⅔, 79 and 66⅔, left by abstracting the Ca and CO_3.

	SEA WATER	SEA WATER	FRANKLIN, BALLSTON	HATHORN, SARATOGA	CONGRESS, SARATOGA	SELTZER, SARATOGA	HATHORN NO. 2, GEYSERS	GURN, WILTON
Cl	55.12	55.01	51.20	54.36	53.17	52.60	52.00	43.23
Br	.18	.13	.44	.21	1.40	.30	.13	.24
SO_4	7.47	8.00	.05	tr.	.11	.20	.05	....
CO_3	.46	.14	.46	.46	.46	.46	.46	.46
Na	30.46	30.47	35.12	35.00	35.00	37.55	40.00	40.00
K	1.16	.96	2.42	.90	1.00	.60	.61	3.74
Ca	1.41	1.67	1.67	1.67	1.67	1.67	1.67	1.67
Mg	3.74	3.53	6.10	5.13	4.30	4.20	4.00	5.23
Rest	....	.09	2.20	1.60	1.91	2.40	1.40	5.40
	100.00	100.00	99.66	99.33	99.02	99.98	100.32	99.97

The first analysis of sea water is the one having the maximum CO_3, and is an average of six from the Black sea. The salinity varied from 22,230 parts in a million to 18,260. The second analysis of sea water has the maximum Ca and is from the Baltic sea. The salinity was 7215 parts per million. In these statements the carbonates are all calculated as normal carbonates, and the salinity is reckoned on the evaporated residue. In the mineral waters, expressed in the same way, the salinity varies from 16,870 parts per million for the Franklin well, and 16,283 for the Hathorn No. 2, to 4062 for the Seltzer.

Now when we critically compare these analyses we see that no mineral spring quite reaches the values in chlorin possessed by the sea water, but in four cases the approximation is very close. If we take away a little magnesium on the assumption that it was furnished by the limestones, the chlorin percentages for these four would be substantially like those of the sea water. So far as chlorin is concerned the parallel is close. On the other hand, the mineral waters are from 5 to 10 actual per cents richer in sodium and for this element no close parallel can be drawn. If we remove some magnesium for the reason just stated, the contrasts will be still further accentuated. In SO_4 the sea water is vastly richer, actually from 37 to hundreds of times as rich as the mineral waters. There is a fundamental difference here which can not be easily explained. The mineral waters are richer in bromine. They are uniformly richer in magnesium. They are both richer and poorer in potassium. On the whole, the lack of SO_4 in the mineral waters and its presence in the sea water as calcium and magnesium sulphate argues strongly against a marine source for the mineral waters. We can not imagine calcium and magnesium removed from connate sea water in any probable reaction in the earth, which would not yield other salts that also fail in the mineral waters. The notable excess of sodium can not easily be explained by a marine source, while the great richness in carbonic acid gas can only be referred to a source in the depths of the earth, probably from some expiring center of igneous activity. The writer is therefore led to the conclusion that both gas and dissolved mineral matter are derived from deep-seated sources.

There is an additional and apparently irrefutable argument. We have in a great many places in the Champlain and Hudson valleys practically the same geological section with the exception that it changes on the north because of the addition of the Chazy limestone. The section is frequently broken across by faults of vastly greater displacement than the one at Saratoga Springs; yet even uncarbonated brine springs are lacking.

If the Saratoga and Ballston springs derive their mineral matter from ancient sea water contained in the local strata, it is extraordinary that we have not abundant brine springs, even if not carbonated, in many localities to the north and south. So extraordinary is it that we are logically forced to abandon the explanation.

We may now direct special attention to the carbonic acid gas. There are four ways in which carbonic acid is produced in nature.[1] The simplest is by the direct oxidation of carbonaceous deposits, such as peat bogs, coal seams, and the like. It is one of the dangerous gases in coal mines, constituting the choke damp of the miner. We have no reason to believe, however, in the existence of carbonaceous beds of this sort beneath Saratoga and much reason to infer their absence. The second method is by the action of some free acid such as sulfuric upon limestone. Sulfuric acid is sometimes produced in nature by the oxidation of pyrites, in the presence of water. If it meets with limestone it destroys the carbonate of lime, evolving carbonic acid gas and forming calcium sulphate. Since hydrated calcium sulphate is the mineral gypsum, gypsum beds have been sometimes explained in this way. We have no reason to infer gypsum beds beneath Saratoga, nor do we find in the waters the calcium sulphate which would be demanded by this reaction. We may dismiss this explanation also.

The third method of formation is by the silicification of limestone. Silicic acid in solution, especially around the borders of still heated masses of igneous rock, displaces the carbonic acid of calcium carbonate and forms calcium silicates. The carbonic acid then migrates. It is possible that some such process as this deep down in the Grenville strata either has taken place or is taking place and that the gas thus liberated is still rising to the surface or has risen and now remains in solution in the waters.

The last and most important explanation of free carbonic acid as it is met in foreign localities, is based on expiring volcanic or igneous action. It is a matter of observation that the copious emission of the gas is one of the characteristic features of volcanoes which are no longer active. As time passes the zone of gas emission appears to widen around them until it finally ceases. The amount furnished is in instances prodigious. One borehole at Sondra in Thuringia, Germany, 197 meters deep, yields daily at a pressure of about 230 pounds to the inch, over 500,000 kilos, or over 1,000,000 pounds of the gas. At another place, Oberlandstein, 6,000,000 litres in 24 hours are obtained, or 20,000 pounds of the gas.[2] The utilization of the gas is the basis of an important industry in Germany and supports a special journal.

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[1] An excellent general summary of the geology of carbonic acid gas is a paper by Rudolph Delkeskamp, Vadose and Juvenile Kohlensäure. Zeitschrift f. prakt. Geologie, Feb. 6, 1906, p. 33.

[2] N. Wender. Die Kohlensäure-industrie, Berlin, 1901, p. 72–73.

We are not definitely assured as to the reaction which produces the gas deep within the earth. Whether it is emitted directly from cooling masses of igneous rock, as is not unreasonable from some things that we know about them, or whether it results from the action of the igneous rock on limestone, perhaps through the intermediation of silicic acid, as was explained in an earlier paragraph, may be a matter of uncertainty.

If we endeavor to apply these views to the specific case of Saratoga, we are reminded of the volcanic plug discovered at Northumberland, on the west bank of the Hudson, about ten miles a little north of west from the springs in the village.[1] The plug is so isolated from all others of its kind and positive evidence of its age is so difficult to obtain, that its time of outbreak is very obscure. Since first studied ten years ago by Professors Woodworth and Cushing, it has been nearly half quarried away for macadam and concrete and its structure and features are much better exposed. If anything they have made it more difficult to understand. The complexity of the stratigraphical relations of the vicinity has been increased by Doctor Ruedemann's discovery of late Cambrian fossils in the slates. These matters will be fully discussed by Professor Cushing in the Bulletin on the Saratoga Quadrangle. The writer has had the privilege of visiting the plug with Professor Cushing and Doctor Ruedemann and of discussing the question at length. That the mass is volcanic seems to me the best explanation, and that it is an elliptical agglomerate representing an old vent and formed of bombs and masses of limestone torn off from the walls of the throat down below, I feel convinced. The excessive alteration argues for an outbreak which probably antedates the Tertiary period, but to what extent I can not say. The plug is so far as known the only purely volcanic rock within the confines of New York, Vermont, or of Massachusetts west of the Connecticut valley.

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[1] The plug was first recognized by J. B. Woodworth in the summer of 1901. It was carefully studied by him and described in the 21st Report of the N. Y. State Geologist, p. r 17–r 24. The petrography was contributed by H. P. Cushing, p. r 24–r 29. Professor Woodworth remarks the similarity with the Triassic traps of the Connecticut valley; and Professor Cushing very cautiously suggests the parallels between the plug and the same occurrences and those of the lower Hudson (i. e. the Palisades) and New Jersey. A Triassic age seemed the best suggestion for a confessedly obscure and uncertain occurrence.

No one could with much reason attribute the carbonic acid gas to the Northumberland plug itself, but the plug does serve to show the former existence of volcanic action and unless it has been thrust westward into its present position by some great reversed fault from an original situation farther east, as will be outlined by Professor Cushing, it may be considered significant to this extent. We may at least state that all the other geological features of Saratoga Springs and Ballston Spa are reproduced in many places northward throughout the Champlain valley. Practically the same geological section is seen. A great number of faults have been mapped and yet no such mineral springs have ever been discovered. The great quantities of carbonic acid gas in the water are distinctive of the two localities, Saratoga Springs and Ballston. The only other visible and distinctive feature of the Saratoga region as compared with the localities farther north is the volcanic plug. One may merely suggest the possibility of some more westerly and deep-seated manifestation of the same sort of activity through whose influence the carbonic acid gas rises through faults to the surface. The tight cover of slates east of the fault may have kept from emergence at the surface the waters in which the gas speedily became dissolved.

Even sodium chlorid itself has been attributed to volcanic sources. Thus Sir Archibald Geikie, in his Text-book of Geology, 4th ed. 1903, I, p. 269, when speaking of volcanic emissions, states: " Sodium chlorid sometimes appears so abundantly that wide spaces of a volcanic cone, as well as of the newly erupted lava, are crusted with salt which can be profitably removed by the inhabitants of the district. Considerable quantities of chlorids may be buried between successive sheets of lava, and in long subsequent times may give rise to mineral springs, as has been suggested with reference to the saline waters, which issue from volcanic rocks of old Red Sandstone and Triassic age in Scotland." Again, on page 469, we find: " Carbonic acid is here and there largely evolved within the earth's crust, especially in the regions of extinct or dormant volcanoes. Subterranean water coming in the way of this gas dissolves it and thereby obtains increased solvent power." Professor L. De Launay of Paris, in a very important work[1] upon the Investigation, Discovery and Management of Mineral Springs, under the caption

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[1] L. De Launay, Recherche, Captage et Aménagement des Sources Thermo-Minerales, Paris, Banday et Cie, 1899.

Carbonated Springs, Origin of the Free Carbonic Acid, page 130, speaks thus of carbonic acid gas, the original French being here rendered into English:

> When we examine the map of an entire country, whereon the mineral springs have been each indicated by a special sign, corresponding to their chemical composition, we soon see a general fact stand out, which could escape us in too detailed study or remain open to question, but which in a comprehensive survey is perfectly plain; it is the almost absolute restriction of springs with free carbonic acid to the regions of Tertiary or recent volcanic activity, such as the Auvergne, Bohemia, the Carpathians, the Apennines, etc.

In a discussion regarding the source of the waters of the Saratoga springs which was held in New York at a meeting of the National Academy of Sciences in November 1911, Mr Waldemar Lindgren raised the point that bromine was present in the waters but that so far as he was aware it had not been reported in volcanic emissions. It is, however, a well-known ingredient of the sea waters. On looking the matter up the writer realizes that bromine is far less abundant than chlorine, probably also less abundant than fluorine and iodine in the volcanic gases, and that it has not been so generally mentioned. Matteucci, however, in reporting upon the Vesuvian eruption of 1895, mentions hydrobromic acid as one of the fumarolic products.[1] It would be surprising if amid the very great quantity of chlorine, its other closely related haloids, bromine, fluorine and iodine were not all present in minor amounts. Both hydrofluoric and hydriodic acids were also observed by Mateucci. Fluorine and iodine have been more often reported than bromine which is, at best, a comparatively rare element.

In addition to the sodium chlorid just cited as a well-known volcanic exhalation, potassium and ammonium chlorid are also cited in the works which give analyses of these products. Sodium carbonate also forms by secondary reactions and in fact practically all the ingredients of the Saratoga mineral waters are reported, except those such as calcium, magnesium, barium, strontium, and iron carbonates, which would be easily dissolved from the limestones by circulating carbonated waters; alumina, iron oxids and silica which might come from these or other rocks through the medium of the same solvent.

The explanation which appeals most strongly to the writer is that the carbonic acid gas, the chlorids, bromids, iodids, fluorids, and sodium carbonate are deep-seated. The sodium carbonate might in part or in whole be dissolved from the feldspars in the old crystalline rocks. The carbonated waters take on calcium and magnesium carbonates from the limestones encountered in their upward journey, more especially from the Little Falls dolomite. They mingle with artesian waters from the west, which may furnish a good portion of the motive power toward the close of the ascent. Their greatest vents lie in or near the fault, which passes through Saratoga Springs, but not all are demonstrably on it. The Gurn spring is near a branch. The course of the fault is less clear at the Geysers, at Ballston and at Round Lake, but if not the same, then some other fault is probably present. For the old Albany well a similar explanation is suggested. The faults furnish the upward passages of the gas and dissolved mineral matter from the depths, but the tight cap of slates above the limestones acts as a roof to prevent their escape, except in the springs and bore holes. The source of the mineral matter and the gas is probably east of Saratoga Springs and Ballston.

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[1] Comptes rendus, 129, 65, 1899.

TABLE I

Analyses by Dr John H. Steel, 1817 and earlier. Grains per gallon of 231 cubic inches

	CONGRESS	COLUMBIAN	WASHINGTON	HAMILTON	FLAT ROCK	HIGH ROCK	PRESIDENT	RED	TAYLOR'S WASHINGTON	TAYLOR'S JACKSON	TAYLOR'S ALEXANDER	ELLIS'S	SULFUR	BALLSTON VILLAGE	BALLSTON LOWS	BALLSTON SULFUR
Muriate of soda	471.5	201.5	231.5	269.5	194.8	210	135	117.58	313.54	240	238.4	188	23.6	159	142	64
Carbonate of lime	178.476	121	127.5	147.5	107.0	115	107.5	97	140	103.8	119.5	110.5	33.1	75.5	64.5	30
Carbonate of soda	16.5	22.5	16.5	24.5	11.2	18	19	24.48	26.46	18	19.6	10	1.4	9	10	6
Carbonate of magnesia	3.356	1.5	2.5	7.9	1.5	.5	2.5	3	5.5	3	7	......	......	2.5	1.5	......
Carbonate of iron	6.168	7.5	6	3.0	7.5	4.5	6	6	4.1	5.2	5.5	7.5	1.9	7	6	4
Total	676	354	384	452	322	348	270	248	489.6	370	390	316	60	253	224	104
Carbonic acid gas, cu. in	343	236	247	284	252.5	243	314	150.5	251	256.5	253	224.5	43.5	210	220	144
Temperature	50° F.	50° F.	48° F.	48° F.	48° F.	48° F.	51° F.	48° F.	48° F.	50° F.	48° F.	47° F.	50° F.	50° F.	52° F.	52° F.
Sulfuretted hydrogen, cubic inches	......	......	......	......	......	......	......	......	......	......	......	......	11	......	......	7

NOTES. All the analyses are taken from "An Analysis of the Mineral Waters of Saratoga and Ballston, etc.," by Dr John H. Steel. Albany. E. & E Hosford, 1817. The Columbian spring was about 15 rods west of the Congress. The Washington was about 50 rods southwest of the Columbian. The Hamilton was about 50 rods northeast of the Congress and was in a marsh. The Flat Rock was about 100 rods down stream from the Hamilton. The High Rock was about 100 rods north of the Hamilton. The President was about 30 rods from the High Rock (presumably north), and in the same valley. The Red spring was northeast of the President, the distance not being given. Taylor's springs were about one mile east of the High Rock and were apparently the same as the Ten springs of today. Three of them were named Washington, Jackson and Alexander. Ellis's spring was about two miles south of the Congress, in a deep valley of the principal northern branch of Kayaderosseras creek. It was obviously near the Geysers and the valley of Coesa creek. The Sulphur spring was two or three miles up Coesa creek from Ellis's spring. The first Ballston analysis was of a spring near the center of the village. Low's spring was about 100 rods down stream. The Ballston Sulphur was twenty feet from the last named.

TABLE 2

Analyses by Dr John H. Steel, 1817–1825, and 1825–1837. Grains per gallon of 231 cubic inches

	WALTON	BALLSTON NEW SPRING	BALLSTON LOW TUBE
Muriate of soda......	274.8	145.0	158.5
Carbonate of soda....	5.2	12.0	13.0
Carbonate of lime....	140.0	61.5	61.54
Carbonate of magnesia	7.0	9.0	8.5
Carbonate of iron....	7.5	7.5	7.5
Silex...............	Small quan.	tr.	tr.
Alumina............	" "	tr.	tr.
Total...........	434.5	235.0	249.04
Carbonic acid gas....	Abundant	Abundant	Abundant
Temperature.........	47° F.	50° F.	50° F.

	CON-GRESS	COLUM-BIAN	WASH-ING-TON	HAMIL-TON	FLAT ROCK	HIGH ROCK	BALLSTON SANS SOUCI	BALLSTON NEW WASH-INGTON
Chlorid of sodium.......	385.0	267	281.5	297.3	148.816	189.10	143.733	89.83
Hydriodate of soda......	3.5	2.56	2.75	3.0	1.33	2.5	1.3	0.7
Bicarbonate of soda......	8.982	15.40	16.5	27.036	20.79	17.538	12.66	18.057
Bicarbonate of magnesia..	95.788	46.71	40.92	35.2	42.70	61.592	39.10	42.042
Carbonate of lime.......	98.098	68.00	92.60	92.4	60.573	69.29	43.407	41.51
Carbonate of iron.......	5.075	5.58	3.25	5.39	5.39	5.58	5.95	3.71
Silex..................	1.5	2.05	1.50	....	tr.	tr.	1.0	1.25
Hydrobromate of potash..	tr.	tr.?	....	tr.	tr.	tr.	....	....
Total.............	597.943	407.30	439.02	460.326	279.649	345.68	247.15	197.099
Carbonic acid gas, cu. in..	311	272.06	262 5	316	287.5	304		
Atmospheric air, cu. in...	7	4.5	6.8	4	6.5	5		

NOTES. The analyses of the previous table together with the first three given on this table appear in the second edition of Doctor Steel's book, published in Saratoga Springs in 1825. The Walton spring was a few rods from the Flat Rock. The New spring of Ballston was uncovered by a freshet in 1817. It was some rods below the Village spring of the previous table. The Low Tube is apparently the Low spring of the earlier edition. The last eight analyses are from a later edition of Doctor Steel's book, published in 1838, just after his death. The determinations were all made anew. He also gives notes but no analyses of the President, Red, Ten springs, and Ellis'. He speaks of the Quaker springs, 10 miles southeast of Saratoga, as containing lime, magnesia, iron and a certain percentage of common salt and soda. The gaseous contents were small. At Ballston the Sans Souci was near Low's spring. The Park spring is credited with 5 grains of carbonate of iron. The New Washington had a spec. gr. of 1.0046. Temperature 51° F.

TABLE 3

Various early analyses. All stated in grains per gallon of 231 cubic inches

	1 CONGRESS	2 CONGRESS	3 CONGRESS	4 UNITED STATES	5 EMPIRE	6 PAVILION	7 ALBANY	8 ALBANY	9 PUTNAM	10 RED	11 UNION	12 WALTON	13 WASHINGTON	14 COLUMBIAN
Chlorid of sodium	434.4	385.44	363.83	424.96	269.70	187.68	504.00	472.00	214.00	83.53	243.62	187 00	182.00	267 00
Carbonate of soda	16.0	.56	7.20	16.88	30.85	4.92	40 00	40.00	14.32[a]	15.33[a]	12.80	2.00	8.00[a]	15.4[a]
Carbonate of magnesia	32.0	56.80	78.62	5.76	41.98[a]	56.92	16.00	12.00	51.60[a]	42.41[a]	84.27	75.00	66.00[a]	46.70[a]
Carbonate of lime	144.0	116.00	86.14	29.20	141.82[a]	52.84	32.00	32.00	68.80[a]	101.26[a]	41.60	26.00	84.00[a]	68.00[a]
Silica	tr.	......	.47	8.00	1.16	......	little	little	.84	3.25	......	......	......	......
Sulphate of soda	......	......	0.65	1.76	......	1.48	......	......	1.68	......	......	......	......	......
Carbonate of iron	......	......	0.84	......	tr.	3.51	8.00	8.00	7.00[a]	......	5.45	1.00	......	......
Total	626.4	558.80	537.75	486.56	485.51	......	600.00	564.00	358.24	165.78	387.74	291.00	340.00	397.1
Carbonic acid gas, cu. in.	312.8	......	284.65	244.00	359.50	......	168.00	......	326.40	......	344.16	326	......	......
Azote	7.2	......	......	......	......	......	......	......	......	......	......	......	......	......
Temperature° F.	......	......	......	50° F.	......	......	51°–52°F	......	......	......	......	......	......	......

NOTES. The first analysis is by J. F. Dana and was made before 1817. This analysis is by mistake attributed to J. D. Dana in Bulletin 32, page 38, United States Geological Survey. The second analysis is by Davy and Faraday, London, as cited in Bulletin 32, United States Geological Survey, page 38. The date is not given but it was obviously early. There was also potassium bromid, tr. sodium iodid, 4.02, iron oxid, 0.64. The third analysis is by J. R, Chilton (1834). There was also potassium and sodium bromid, 5.92; alumina, 0.32, atmospheric air, 5.41 cubic inches. The fourth analysis of the United States spring is by L. C. Beck. Mineralogy of New York, 137 (1842). No. 5 was by E. Emmons and is quoted in Bulletin 32, page 38. There was also 12.0 of sodium iodid or iodine. No. 6 is by J. R. Chilton (1840) and is taken from Bulletin 32, United States Geological Survey, page 40. It contained calcium phosphate, 0.19; potassium bromid and sodium iodid, 2.59; alumina, 0.42; atmospheric air, 5 30 cubic inches. The first analysis of the Albany spring is by William Meade M.D.; the second by L. C. Beck. Both are taken from Beck's Mineralogy of New York, 140 1842. The spring is in Albany, N. Y., not Saratoga. No. 9' by J. R. Chilton (1840) and is taken from Bulletin 32, United States Geological Survey, page 40. It contained also sodium phosphate, 0.21, potassium bromid, tr.; sodium iodid, 2, alumina, 56, atmospheric air, 6.40 cubic inches. No. 10 by Appleton, date not given in Bulletin 32, United States Geological Survey, page 40. Also potassium chlorid, 6.86 iron oxid and alumina, 2.10. No. 11 by J. R. Chilton (1841) taken from Bulletin 32, United States Geological Survey, page 41. Also sodium iodid, 3.60; alumina and silica, 1.57. Atmospheric air, 4.62 cubic inches. No. 12 by E. Emmons (1839). The spring is also called the Iodine or Star. Analysis taken from Bulletin 32, United States Geological Survey, page 41. Also sodium iodid, 3.50. Atmospheric air, 4 cubic inches. No. 13 by J. R. Chilton (1843). Analysis furnished by J. C. Minor, jr. No. 14 by E. Emmons. Analysis furnished by J. C. Minor, jr.

[a] Bicarbonates.

TABLE 4

Analyses in grains per U. S. gallon made by Dr Charles F. Chandler, 1860–1875, and taken from F. A. Cairn's Notes on Quantitative Analysis

	GLACIER SPOUTING WELL	GEYSER SPOUTING WELL	HATHORN	UNION	CONGRESS	PAVILION	EMPIRE	HIGH ROCK
Chlorid of sodium	702.239	562.080	509.968	458.299	400.444	459.903	506.630	390.127
Chlorid of potassium	40.446	24.634	9.597	8.733	8.049	7.660	4.292	8.974
Bromid of sodium	3.579	2.212	1.534	1.307	8.559	0.987	0.266	0.731
Iodid of sodium	0.234	0.248	0.198	0.039	0.138	0.071	0.606	0.086
Fluorid of calcium	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
Bicarbonate of lithia	6.247	7.004	11.447	2.605	4.761	9.486	2.080	1.967
" " soda	17.624	71.232	4.288	17.010	10.775	3.764	9.022	34.888
" " magnesia	193.972	149.343	176.463	109.685	121.757	76.267	42.953	54.924
" " lime	227.070	170.392	170.646	96.703	143.399	120.169	109.656	131.739
" " strontia	0.082	0.425	tr.	tr.	tr.	tr.	tr.	tr.
" " baryta	2.083	2.014	1.737	1.703	0.928	0.875	0.070	0.494
" " iron	0.647	0.979	1.128	0.269	0.340	2.570	0.793	1.478
Sulphate of potassa	0.252	0.318	tr.	1.818	0.889	2.032	2.769	1.608
Phosphate of soda	0.010	tr.	0.006	0.026	0.016	0.007	0.023	tr.
Biborate of soda	tr.	tr.	tr	tr.	tr.	tr.	tr.	tr.
Alumina	0.458	tr.	0.131	0.324	tr.	0.329	0.418	1.223
Silica	0.699	0.665	1.260	2.653	0.840	3.155	1.458	2.260
Organic matter	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
Total	1 195.582	991.546	888.403	701.174	700.895	687.275	680.436	630.500
Carbonic acid gas	465.458	454.082	375.747	384.969	392.289	332.458	344.669	409.458
Density	....	1.012	1.0115	....	1.096	1.0095	....	1.0092
Temperature	....	46° F.	....	48° F.	52° F.	....	....	52° F.

TABLE 4 (*concluded*)

Analyses in grains per U. S. gallon made by Dr Charles F. Chandler, 1860–1875, and taken from F. A. Cairn's Notes on Quantitative Analysis

	STAR	CRYSTAL	VICHY	UNITED STATES	SELTZER	BALLSTON ARTESIAN LITHIA	FRANKLIN ARTESIAN	CONDE DENTONIAN
Chlorid of sodium	398.361	328.468	128.689	141.872	134.291	750.030	659.344	645.481
Chlorid of potassium	9.695	8.327	14.113	8.624	1.335	33.276	33.930	9.232
Bromid of sodium	0.571	0.414	0.990	0.844	0.630	3.643	4.665	2.368
Iodid of sodium	0.126	0.066	tr.	0.047	0.031	0.124	0.235	0.225
Fluorid of calcium	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
Bicarbonate of lithia	1.586	4.326	1.760	4.847	0.899	7.750	6.777	10.514
" soda	12.662	10.064	82.873	4.666	29.428	11.928	94.604	34.400
" " magnesia	61.912	75.161	41.503	72.883	40.339	180.602	177.868	158.348
" " lime	124.459	101.881	95.522	93.119	89.869	238.156	202.332	178.484
" " strontia	tr.	tr.	tr.	0.018	tr.	0.867	0.002	0.189
" " baryta	0.096	0.726	0.593	0.909	tr.	3.881	1.231	4.739
" " iron	1.213	2.038	0.052	0.714	1.703	1.581	1.609	2.296
Sulphate of potassa	5.400	2.158	tr.	tr.	0.557	0.520	0.762	tr.
Phosphate of soda	tr.	0.009	tr.	0.016	tr.	0.050	0.011	0.003
Biborate of soda	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
Alumina	tr.	0.305	0.473	0.094	0.374	0.077	0.263	0.395
Silica	1.283	3.213	0.758	3.184	2.561	0.761	0.735	1.026
Organic matter	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
Total	617.367	537.155	367.326	331.837	302.017	1 233.246	1 184.368	1 047.700
Carbonic acid gas	407.650	317.452	383.071	245.734	324.080	423.114	460.066	358.345
Density	1.0091	1.006	....	1.0035	1.0034	1.0159	1.0135	1.0125
Temperature	52° F.	50° F.	50° F.	....	50° F.	52° F.	52° F.	49° F.

TABLE 5

Analyses of Saratoga waters by Dr Charles F. Chandler, recast as ions in parts per million

	GLACIER SPOUTING	GEYSER SPOUTING	HATHORN	UNION	CONGRESS	PAVILION	EMPIRE	HIGH ROCK	STAR	CRYSTAL	VICHY	UNITED STATES	SELTZER
Cl	7 571.8	5 997.6	5 338.0	4 797.4	4 195.6	4 806.2	5 242.2	4 097.3	4 188.2	3 456.1	1 441.8	1,533.4	1 396.2
Br	47.6	28.9	20.4	17.3	112.9	13.1	1.9	9.7	7.5	5.5	13.0	11.2	8.5
I	3.4	3.6	2.7	0.6	2.0	1.0	8.7	1.2	1.8	0.9	tr.	0.6	0.4
HCO_3	6 059.5	5 374.0	4 993.2	3 094.0	4 519.9	2 877.9	2 189.4	2 977.6	2 694.5	2 618.0	2 896.0	2,398.1	2 142.0
SO_4	2.4	3.0	tr.	17.0	8.4	19.0	25.9	15.1	50.7	20.2	tr.	0.2	5.2
PO_4	0.1	tr.	0.1	0.3	0.2	0.1	0.3	tr.	tr.	0.1	tr.	0.2	tr.
SiO_2	11.9	11.9	21.4	45.1	14.3	53.6	24.8	38.4	21.8	54.6	12.8	54.1	43.5
Na	4 790.6	4 267.0	3 435.7	3 148.4	2 759.1	3 095.3	3 450.2	2 774.7	2 724.1	2 244.2	1 249.7	973.4	1 037.0
K	392.1	221.0	85.0	93.5	78.2	83.8	59.5	92.1	127.5	90.6	125.8	76.7	16.1
Li	10.2	11.9	20.4	4.6	8.5	16.7	3.6	3.4	2.8	7.6	3.1	8.5	1.6
Ca	945.2	710.8	712.3	402.9	598.4	501.3	457.3	549.6	603.5	425.0	397.8	388.6	374.9
Ba	18.4	18.4	15.8	15.4	8.4	7.9	0.6	4.5	0.9	6.6	5.4	8.2	tr.
Sr	.6	2.7	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	0.1	tr.
Ng	592.6	417.1	492.7	306.5	340.3	213.2	120.1	153.5	173.4	210.0	115.9	203.7	112.7
Fe	3.5	5.4	6.8	1.4	1.9	14.1	4.4	8.1	6.7	11.2	0.2	3.9	9.5
Al	4.1	tr.	1.2	2.9	tr.	3.1	3.8	11.1	tr.	2.8	4.1	0.8	3.4
Total	20 325.0	16 856.0	15 102.8	11 920.0	11 915.0	11 583.5	11 567.2	10 718.5	10 495.0	9 132.4	6 244.5	5 641.0	5 134.0

TABLE 6

Various analyses of date later than 1850. Grains per gallon

	1 EUREKA	2 EXCELSIOR	3 HAMILTON	4 KISSINGEN	5 KISSINGEN	6 SARATOGA A	7 CONGRESS	8 CONGRESS	9 HATHORN	10 STAR
Sodium chlorid	166.81	370.64	298.66	338.50	135.5	65.30	550.8	406.6	478.7	124.5
" iodid	4.67	4.24	3.59	0.04	....	....	....	....	....	....
" bicarbonate	8.75	15.00	34.25[a]	67.62	76.6	6.75	10.9	15.5	17.6	4.2
" sulphate	....	1.32	....	....	....	2.50	....	....	....	....
Potassium chlorid	....	....	....	16.98	16.9	0.36	26.1	40.0	32.8	0.0
" bromid	1.57	tr.	....	....	....	....	....	....	....	....
Calcium bicarbonate	41.32	77.00	97.99[a]	140.26	40.2	56.85	149.8	88.1	147.2	31.7
Magnesium bicarbonate	29.34	32.33	39.06[a]	70.47	70.4	20.48	138.1	42.1	130.5	9.4
" sulphate	2.15	....	....	....	....	0.29	....	....	....	....
Iron bicarbonate	3.00	3.22	4.62[a]	1.56	....	1.72	....	....	....	....
Alumina	0.23	....	....	tr.	....	0.38	....	....	....	....
Silica	0.53	....	1.00	1.28	....	1.46	....	....	....	....
Total	258.37	503.75	479.17	636.71	339.6	....	875.7	592.3	806.8	169.8
Carbonic acid gas, cubic inches	239.00	250	320	361.50	....	....	....	....	....	....
Atmospheric air, cubic inches	....	....	....	....	....	....	....	....	....	....

No. 1, Allen, analyst, United States Geological Survey, Bulletin 32, page 39. No. 2, Allen, analyst (1879), idem. Also strontium sulphate, tr., sodium silicate, 4; potassium silicate, 7.00. No. 3, Allen, analyst, as under No. 1. No. 4, Sharples, analyst (1872), as under No. 1. Also strontium bicarbonate, tr.; lithium bicarbonate, 5.13; barium bicarbonate, 0.99; potassium sulphate, tr.; sodium bromid, 1.80; calcium fluorid, tr. No. 5, Nichols (1896), from J. C. Minor, jr. No. 6, J. G. Pohle, analyst, as under No. 1. Also lithium bicarbonate, 1.72; calcium sulphate, 0.45; potassium sulphate, 0.37; calcium chlorid, tr.; magnesium chlorid, tr.; organic matter, tr. No. 7, L. W. Mears (1892), from J. C. Minor, jr. No. 8, Wheeler (1906), from J. C. Minor, jr. No. 9, C. F. Chandler (1884), from J. C. Minor, jr. No. 10, Smith (1904), from J. C. Minor, jr. No. 11, Ellery (no date), from J. C. Minor, jr.

[a] Normal carbonate, not bicarbonate.

TABLE 6 (*concluded*)

Various analyses of date later than 1850. Grains per gallon

	11 HIGH ROCK	12 VICTORIA	13 LINCOLN	14 MAGNETIC	15 CARLSBAD 3	16 CARLSBAD 1	17 CHIEF	18 PUTNAM	19 STRONG	20 AINSWORTH
Sodium chlorid	86.8	186.2	315.2	69.0	486.7	670.5	86.9	210.9	265.2	448.1
" iodid	....	....	....	....	....	....	....	....	....	....
" bicarbonate	19.7	32.8	32.8	16.0	52.5	12.0	74.1	19.8	68.9	5.7
" sulphate	....	....	....	....	....	....	....	....	....	....
Potassium chlorid	1.1	16.1	22.9	8.0	33.5	45.2	6.5	2.3	24.8	6.2
" bromid	....	....	....	....	....	....	....	....	....	....
Calcium bicarbonate	20.4	112.5	176.2	86.7	173.7	218.2	72.2	109.4	123.9	100.2
Magnesium bicarbonate	8.1	79.8	108.5	35.0	118.1	155.0	53.6	63.1	79.2	146.8
" sulphate	....	....	....	....	....	....	....	....	....	....
Iron bicarbonate	....	....	....	....	....	....	....	....	....	....
Alumina	....	....	....	....	....	....	....	....	....	....
Silica	....	....	....	....	....	....	....	....	....	....
Total	136.1	427.4	655.6	214.7	864.5	1,100.9	293.3	405.5	562.0	707.0
Carbonic acid gas, cubic inches	....	....	....	....	....	....	....	....	....	....
Atmospheric air, cubic inches	....	....	....	....	....	....	....	....	....	....

No. 12. Perkins (no date), from J. C. Minor, jr. No. 13. Perkins (1896), from J. C. Minor, jr. No. 14. Duffield (no date), from J. C. Minor, jr. No. 15. Smith (1901), from J. C. Minor, jr. No. 16. C. F. Chandler (1887), from J. C. Minor, jr. No. 17. Perkins (no date), from J. C. Minor, jr. No. 18. Perkins (1891), from J. C. Minor, jr. No. 19. Perkins (1902), from J. C. Minor, jr. No. 20. L. W. Mears (1889), from J. C. Minor, jr.

TABLE 7

Analyses of Saratoga waters by J. K. Haywood and B. H. Smith, United States Department of Agriculture, 1905. Parts per million in ions.

	HATHORN	CARLSBAD	LINCOLN	HATHORN	CONGRESS	CHIEF	GEYSER	CHAMPION	PEERLESS
Cl	4 674.7	4 419.6	4 068.4	3 685.5	3 327.9	2 982.7	1 025.1	2 799.1	1 773.1
Br	47.1	40.3	76.0	26.9	26.8	20.2	11.8	13.5	16.8
I	1.7	1.6	1.9	1.5	0.8	1.2	1.0	0.2	1.0
HCO_3	4 147.1	4 244.5	4 221.0	3 585.6	3 573.3	3 966.7	4 353.2	1 604.3	2 634.4
SO_4	3.4	2.8	3.5	5.6	8.7	5.3	1.4	20.0	4.0
PO_4	....	....	....	....	....	....	....	....	....
SiO_2	16.2	13.5	32.7	19.6	19.8	15.0	20.8	12.3	14.8
Na	2 951.8	3 014.5	2 688.0	2 430.7	2 199.3	2 182.0	2 010.9	1 839.9	1 298.5
K	197.8	237.8	243.7	197.2	192.0	197.7	29.0	60.0	94.7
Li	7.4	5.3	1.8	0.5	5.4	2.8	3.6	0.9	0.4
Ca	765.0	628.6	675.8	650.7	562.1	601.4	116.4	348.3	530.4
Ba	7.5	10.1	11.7	5.5	7.1	1.1	2.6	6.3	2.1
Sr	....	tr.	....	tr.	....	....	tr.	....	....
Mg	328.0	298.8	325.9	228.8	278.2	217.1	60.6	81.1	90.9
Fe Al	6.7	13.1	13.9	9.8	14.7	3.7	8.4	.8	5.6
NO_3	....	....	tr.	....	....	....	tr.	tr.	....
NO_2	tr.	....	....	....	tr.	tr.	....	....	tr.
Mn	....	....	....	....	....	....	....	tr.	....
NH_4	12.8	13.4	7.3	10.7	10.3	8.9	11.4	3.1	5.9
Total	13 170.3	12 949.6	12 371 .6	10 858.6	10 232.7	10 207.0	7 656.2	6 790.2	6 472.6

TABLE 7 (*concluded*)

Analyses of Saratoga waters by J. K. Haywood and B. H. Smith, United States Department of Agriculture, 1905. Parts per million in ions.

	MAGNETIC	ARONDACK	STAR	SELTZER	VICTORIA	VICHY	VICHY	HIGH ROCK	HIDE'S FRANKLIN, BALLSTON
Cl	1 313.4	1 185.9	1 325.8	720.1	1 238.8	915.0	893.3	483.3	7 179.0
Br	11.8	11.8	0.2	6.7	20.2	tr.	tr.	6.7	60.0
I	0.3	none	tr.	0.3	tr.	tr.	tr.	.2	2.3
HCO_3	1 816.8	275.5	472.4	1 114.3	365.2	778.2	684.3	1 114.0	6 566.0
SO_4	2.3	503.9	47.0	20.2	27.1	20.2	16.7	15.7	3.0
PO_4	....	....	2.3	....	....	....	....	....	....
SiO_2	42.7	9.2	13.7	40.4	14.8	16.2	14.7	33.4	27.6
Na	849.7	827.3	878.1	459.6	822.0	828.8	772.1	348.0	4 833.0
K	56.9	144.7	23.1	48.4	140.4	3.9	3.8	34.3	346.0
Li	3.2	2.5	tr.	0.1	0.2	0.1	0.6	0.9	15.5
Ca	326.4	25.7	120.5	247.0	8.9	48.7	41.3	223.9	991.0
Ba	4.4	0.1	0.4	0.7	....	....	0.1	0.7	13.1
Sr	tr.	....	....	....	....	....	....	....	tr.
Ng	122.8	90.6	25.4	67.5	21.6	10.1	9.1	60.6	469.0
Fe Al	97.8	3.5	3.2	5.1	4.2	2.2	4.2	12.3	21.4
NO^1	tr.	11.9	44.3	4.4	....	....	tr.	6.6	....
NO_2	tr.	0.02	tr.	tr.	....	....	tr.	....	....
Mn	....	....	....	....	....	....	....	....	tr.
NH_4	3.4	0.2	0.3	2.6	0.1	0.9	0.7	1.5	14.5
Total	4 675.9	3 094.2	2 958.0	2 736.8	2 663.5	2 629.2	2 440.9	2 347.2	20 542.6

Analyses of the salts dissolved in the spring waters of Saratoga and Ballston

SPRING		ANALYST	NA CL	CA (HCO₃)₂	MG (HCO₃)₂	NA HCO₃	KCL	TOTAL	GRAINS PER GALLON
Ainsworth	'89	Mears	63.3	14.2	20.8	.8	.9	100.	707.0
Arondack	'88	Sharples	53.5	22.1	11.0	10.6	2.7	99.9	633.6
"	'96	Nichols	39.9	11.8	20.6	22.4	5.0	99.7	339.6
"	'03	Hayward	74.3	4.4	10.0	....	11.2	99.9	134.7
Ballston Act.	'71	Chandler	62.0	19.6	14.9	1.0	2.7	100.2	1213.9
" Frankl.	'71	"	56.4	17.6	15.2	8.1	2.9	100.2	1167.9
Carlsbad 1	'87	Chandler	61.0	19.8	14.1	1.1	4.1	100.1	1100.9
Carlsbad 3	'01	Smith	56.0	20.0	13.7	6.1	3.9	99.7	864.5
"	'03	Hayward	54.0	20.0	14.2	8.7	3.2	100.1	742.3
Champion	'72	Chandler	59.2	19.2	16.4	1.5	3.4	99.7	1181.1
"	'03	Hayward	67.5	21.0	7.3	2.7	1.4	99.9	390.2
Chief	'98	Perkins	29.8	24.6	18.3	25.2	2.2	100.1	293.3
"	'03	Hayward	45.5	24.6	13.0	13.5	3.3	100.2	587.3
Coesa	'11	N. Y. Dept. of Health	49.4	24.5	9.8	12.2	4.0	99.9	707.5
Columbian	?	Emmons	67.4	17.2	11.8	3.9	....	100.3	397.1
Congress	'30	Steel	59.5	24.2	14.8	1.4	....	99.9	647.0
"	'43	Chilton	56.0	21.4	21.0	1.7	....	100.2	650.6
"	'71	Chandler	58.4	20.9	17.7	1.5	1.1	99.6	684.1
"	'92	Mears	63.5	17.2	15.8	1.2	3.0	100.7	875.7
"	1902	Hayward	51.3	22.4	16.6	6.3	3.4	100.0	585.5
"	1906	Wheeler	68.6	14.9	7.1	2.6	6.8	100.0	592.3
Empire	'52	Emmons	54.8	28.8	8.5	7.9	....	100.0	493.1
"	'71	Chandler	75.0	16.2	6.4	1.3	0.6	99.5	672.4
Eureka	?	Allen	68.0	16.7	11.9	3.5	....	100.1	246.1
Flat Rock	'30	Steel	48.0	31.2	13.8	6.8	....	99.8	310.0
" "	'71	Chandler	43.0	38.6	11.5	3.6	3.1	99.8	253.8
Geyser	'71	Chandler	57.5	17.4	15.3	7.3	2.5	100.0	977.4
"	1903	Hayward	21.2	6.3	4.8	67.3	0.5	100.1	437.6
Hamilton	'30	Steel	65.7	20.4	7.8	6.1	....	99.9	451.9
Hathorn	'71	Chandler	58.6	19.6	20.2	.5	1.1	100.0	870.6
"	'84	"	59.1	18.2	16.1	2.2	4.1	99.7	806.8
Hathorn	1902	Hayward	56.5	23.8	15.6	1.4	2.9	100.2	757.5
"	1903	"	53.5	24.5	12.9	5.5	3.4	99.8	625.7
Hathorn No. 2.	1911	N. Y. State Dept. of Health	52.4	19.8	14.5	12.7	.6	100.0	1216.1
High Rock	'30	Steel	56.1	20.5	18.4	5.0	....	100.0	337.0

Analyses of the salts dissolved in the spring waters of Saratoga and Ballston—(*continued*).

SPRING		ANALYST	NA CL	CA (HCO₃)₂	MG (HCO₃)₂	NA HCO₃	KCL	TOTAL	GRAINS PER GALLON
High Rock	'71	Chandler	63.0	21.0	8.9	5.7	1.5	100.1	620.4
" "	1903	Hayward	33.2	40.6	16.2	7.6	2.7	100.3	129.4
" "	1906?	Ellery	64.0	14.7	5.9	14.5	.8	99.9	136.1
Lincoln	'96	Perkins	48.0	27.0	16.5	5.5	3.5	100.5	655.6
"	1903	Hayward	52.6	22.7	15.8	5.4	3.2	99.7	704.6
Magnetic	?	Duffield	32.1	40.3	16.3	7.5	3.7	99.9	214.7
"	1903	Hayward	47.0	30.4	16.7	3.4	2.2	99.7	253.8
Paterson	'88	Chandler	52.0	24.8	17.1	3.5	2.2	99.6	519.0
Pavilion	'40	Chilton	49.3	22.5	26.0	....	2.1	99.9	379.7
"	'71	Chandler	69.0	18.0	11.4	.6	1.2	100.2	667.5
Peerless	'88	Chandler	46.4	31.6	13.3	6.1	2.5	99.9	412.1
"	1903	Hayward	43.4	33.8	8.6	11.8	2.5	100.1	371.5
Putnam	?	Chandler	43.0	25.2	27.9	1.3	2.4	99.8	621.9
"	'91	Perkins	52.0	27.0	15.5	4.9	.6	100.0	405.5
Red	?	Appleton	33.1	40.4	17.0	6.1	2.7	99.3	249.3
Royal	'88	Chandler	52.0	28.7	16.0	1.2	1.8	99.7	508.9
Saratoga A	'65	Pohle	87.0	8.8	3.1	1.0	.6	100.5	649.7
Seltzer	'71	Chandler	45.5	30.4	13.7	10.0	.4	100.0	295.0
Star	'71	Chandler	65.5	20.5	10.2	2.1	1.6	99.9	606.8
"	'95	"	41.7	36.2	14.5	5.6	2.1	100.1	328.8
"	1903	Hayward	76.8	17.2	4.6	....	1.2	99.8	162.7
"	1904	Smith	73.0	18.8	5.5	2.5	....	99.8	169.8
Strong	1902	Perkins	47.0	22.0	14.1	12.3	4.5	99.9	562.0
Union	'71	Chandler	66.3	14.1	16.0	2.5	1.3	100.2	685.4
Vichy	'71	Chandler	35.4	26.4	11.2	22.9	3.9	99.8	362.5
"	1902	Hayward	58.3	6.4	2.4	33.0	0.3	100.4	149.4
"	1903	"	61.6	6.7	2.3	29.1	0.3	100.0	138.0
Victoria	'90	Perkins	43.5	26.2	18.7	7.7	3.9	100.0	427.4
"	1903	Hayward	72.0	1.4	5.0	11.8	9.8	100.0	148.8
Washington	'30	Steel	58.0	30.4	8.5	3.3	....	100.2	485.0
"	'43	Chilton	53.5	24.7	19.5	2.3	....	100.0	340.0

NOTE. The above analyses were chiefly compiled by J. C. Minor, Jr. To Mr Minor's original series a few very recent ones have been added. Thanks are due Mr Minor for the use of his notes.

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New York State Education Department
Science Division, September 9, 1911

Hon. Andrew S. Draper LL.D.
Commissioner of Education

SIR: I have the honor to transmit to you herewith the manuscript and maps of a report entitled *The Glacial Waters in the Black and Mohawk Valleys,* prepared by Doctor Herman L. Fairchild, a member of the staff of this division, in continuation and completion of his study of the development of the water system of the State, and I recommend that it be published as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

STATE OF NEW YORK
EDUCATION DEPARTMENT
COMMISSIONER'S ROOM

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Director State Museum and State Geologist

STATE HALL, ALBANY, N. Y.

tate Museum

RKE, Director

ulletin 160

AL WATERS

THE

HAWK VALLEYS

BY

HERMAN L. FAIRCHILD

INTRODUCTION: OUTLINE OF THE GLACIAL HISTORY

This paper is essentially a continuation of the one forming State Museum Bulletin 127, "Glacial Waters in Central New York." In that paper was given the history of the glacial lakes and the ice-border drainage as far east as Oneida. While the features there described are quite clear as to their origin, the relationship of the phenomena in time and causality are somewhat uncertain, in the present state of our knowledge of the behavior of the ice margin during its recession across the State. It was there stated that the oscillations of the glacier were probably greater and the history more complicated than now recognized. In the present writing there is similar complication, with the additional problem of correlating the sequence of events in the Ontario basin with those in the Mohawk and Hudson valleys. For the Black river basin the history is comparatively clear, but not so for the Mohawk-Hudson. The writer aims to give an outline of the dramatic history and lay the foundation for future detailed work.

The study of the Black valley was mainly during the summers of 1907 and 1908, though some features had been noted in earlier years. It was the intention to submit the matter for publication in 1908 but the need of revision of the Watertown sheet caused delay and it is included here.

A concise outline of the history described in the following writing will be helpful to the reader. As the large physiographic relief we have the elevated tract of the Adirondacks surrounded by low and broad valleys; the Champlain-Hudson on the east, the Mohawk on the south, the Ontario on the southwest and west, and the St Lawrence on the northwest and north. The highest point in all this ring of lowland is the col at Rome, about 430 feet above tide, the head of the Mohawk valley which is the connecting channel between the Ontario and Hudson valleys.

As the Labradorian ice body, which had at its maximum covered practically the entire State, waned and lost in thickness the Adirondack heights appeared above the ice field, standing as an island in the ice sheet, although local or stream glaciers probably occupied for a time some of the higher valleys. The high Catskill-Helderberg mass must have already been deserted by the ice sheet, and consequently there was left a strait or neck of ice in the Mohawk valley connecting the Ontarian and Hudsonian ice lobes. This stage in the ice retreat is shown in plate 12.

The removal of the ice was partly by evaporation but chiefly by melting and water must have collected about the base of the Adirondack island, forming a chain of lakes in the depressions. This water would fill all the crevasses in the ice margin and to some extent would penetrate in and beneath the shallower ice, but it is not believed possible for the water to have found escape through or beneath the deep ice which lay in the Ontario and Hudson valleys. Its only possible ultimate escape must have been over and across the strait of ice south of the Adirondacks. Some of the extensive sand plains, even in the heart of the mountains and with altitude over 1400 feet, must belong to this episode in the drainage.

With the continued waning of the ice body the neck of ice in the Mohawk valley was melted away and was supplanted by a lake held between the two opposing ice lobes, the Hudsonian lobe pushing up the Mohawk valley from the east and the Ontarian lobe blocking the valley on the west. This stage is shown in plates 13–15.

The Mohawk glacial waters were lowered and finally extinguished by the weakening and recession of the Hudsonian ice in the vicinity of Schenectady (see plates 14–16).

Contemporary with the Mohawk glacial waters were waters held in the valley of the Black river by the ice blockade on the north, with earlier outflow southward into the Mohawk lakes. The later escape of the Black waters was westward into Lake Iroquois, in the vicinity of Copenhagen and Carthage (see plate 17).

The glacial lake history of the Mohawk valley must have been contemporaneous with only the earlier glacial waters in central New York, lakes Watkins and Newberry (see no. 19 of the bibliographic list, Bulletin 127, and plates 34, 35), for the reason that the central New York waters of later time found free eastward escape through the Mohawk valley at the lowest levels.

Doubtless there were readvances and reretreats of the ice fronts and restorations of the lakes which we can not now recognize, but finally the Ontarian ice permanently receded from the Oneida-Rome district and Lake Iroquois was established with its long-continued outlet at Rome to the Mohawk-Hudson.

As the territory involved in this history has considerable north and south distance it is necessary to recognize the deformation or warping of the land which has taken place since the ice removal. It is certain that in the Ontario district a northward lifting of two or three feet per mile has occurred. In this paper the northward uplift is counted as two feet per mile, in correlation of altitudes, which corresponds to the figure used by Professor Woodworth for the Hudson district. The east and west deformation is so small that for the present it is neglected.

To save repetition the terms col, notch and pass are used as equivalents in this writing; and when a pass was occupied by a river it is termed outlet, channel, or escape.

BLACK VALLEY GLACIAL WATERS

PHYSIOGRAPHY

New York State, because of its peculiar physiography, probably surpasses any other district of equal area in the world in the number and excellence of its Pleistocene glacial lakes. Taking into account the several elements involved in the production and life of a glacial lake, the ice-dammed waters held in the basin of the Black river, in Jefferson and Lewis counties, affords one of the finest examples. The reasons for this excellence lie in the favorable attitude, direction, dimensions and relations of the valley; the simplicity and clearness of its history; the three distinct stages with different directions of overflow; the pronounced channels and deltas due to the outdrainage; and the remarkable development of sand plains built on the east wall of the valley by the indrainage from the Adirondacks.

The Genesee valley waters probably have no rival in the world in the number of distinct stages, nor in the number of far-separated great river systems to which the waters at different times were contributed; but the greater simplicity of the Black valley lake makes it a more typical and suitable example for study.

The district involved in this history is partially mapped in Sackett Harbor, Watertown, Carthage, Port Leyden, Boonville, Remsen and Oriskany sheets of the State topographic map. The map of the quadrangle north of the Port Leyden and east of the Carthage sheets is not yet available. The drainage of the area is shown in the sketch map, plate 1, while details are shown in plates 2–4.

The Black river carries the heavy drainage of a large area on the west slope of the Adirondack highland. The river has its source in the district of Ice Cove mountain, in the east edge of Herkimer county, North lake being an expansion of its headwaters. For something over 20 miles its course lies southwest, when it swings to northwest passing through Forestport and Hawkinsville. In this upper reach of about 30 miles the river has no pronounced valley, but some three miles past Hawkinsville, and three miles east of Boonville, it enters the head of the conspicuous and capacious valley which popularly bears its name. This valley extends northwest 40 miles to Carthage where it opens into the broad St Lawrence lowland. From Carthage the river curves around to the west and flowing through open country with only a shallow, postglacial channel, passes through the city of Watertown, and enters Lake Ontario at Dexter, near Sackett Harbor.

developed by millions of years of weathering and stre

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rough the city of W [illegible], and enters Lake Ontario at
, near Sackett Harbor.

A series of parallel streams from the Adirondacks joins the Black river on the east, two of which, the Moose and Beaver, are even larger than the Black river proper. Three factors produce this heavy drainage: the large area, the high altitude and the west-facing attitude, the two latter producing the condensation of moisture from the prevailing westerly winds. In glacial time the wind direction was probably similar to the present and we have every evidence that in this area the precipitation and drainage were very large.

The tributaries to the river from the west are short and weak, with the exception of the Deer river which joins a few miles above Carthage. The lack of western tributaries is due to the narrowness and steepness of the west wall of the basin and its lee position with reference to moisture-laden winds.

The prominent physiographic feature of the Black river basin is the Boonville-Carthage valley. Boonville is situated at the lowest col or pass between Black river waters and drainage to the Mohawk, through the Lansing kill, the altitude of the divide being about 1130 feet. (The summit level of the canal, in a rock cut, is 1120.) Carthage lies on the west side of the mouth of the valley, with altitude of 740 feet on the river bridge.

The west wall of the valley rises steeply in scarps and terraces of limestone until capped by shales at the height of 1800 to 1900 feet. The east wall, with irregular topography, rises slowly into the Adirondacks. The topographic contrast between the two sides of the valley is well shown in plate 3.

The mantle of drift on the west valley wall is scanty; but on the east slope the glacio-lacustrine deposit is remarkably heavy (see p. 15). Crystalline rocks underlie the east slope and the valley bottom and appear in places along the foot of the west slope, conspicuous from the railroad. Bosses of the crystallines project up through the alluvium of the valley, producing the peculiar topography indicated by the contouring on the Carthage sheet east and north of the city. These protruding masses, developed by atmospheric erosion in preglacial time and rubbed into smoothness by the ice abrasion and then half buried in stream and lake deposits, are conspicuous features at many points in the valley. Tens of thousands of huge blocks of the crystallines have been spread by the glacier over the country to the southward, especially along the moraine belt extending southeast from Boonville, as shown in plate 18.

Apparently this great north-sloping valley of the Black river was developed by millions of years of weathering and stream work along the belt of contact between the old crystallines and the onlapping Ordovicic sediments; and during the development of the valley the axis of the valley has shifted westward against the outcrop of the sedimentaries.

OUTLINE OF THE LAKE HISTORY

This history is concerned with the waning and disappearance from the region of the latest or Wisconsin ice sheet, though it is quite probable that this history may be a duplication of that of earlier ice recessions. Some topographic features, like those in the Watertown district (the Rutland Hollow valley for example), may be the cumulative effect of multiple advances and recessions of the ice sheets.

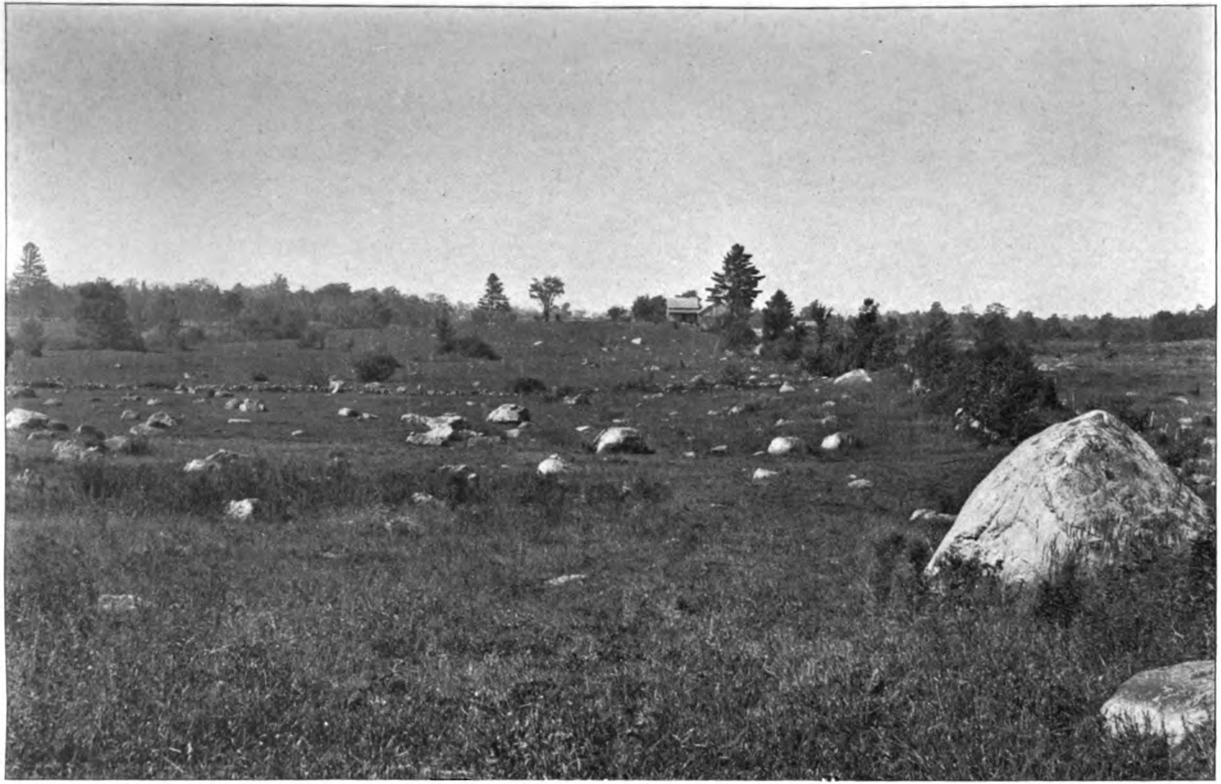
The three broad elements in the history are: (1) the larger features of the land relief (described above), or the topographic control over the ice movement and the water flow; (2) the waning ice body on the north, acting as a receding dam and holding the imprisoned waters up to certain outlets of escape; (3) the impounded waters finding lower and lower escape in different directions, as shown by the outlet channels and the lake plains.

The glacial waters of the Black valley had four main stages, determined by four principal directions of escape. The first and highest stage was that of waters not limited to the Black valley but extending into the Mohawk area and controlled by outlets from the latter. The second stage had overflow to the southeast, through Remsen into the waters held in the Mohawk valley, the altitude of the channel heads being 1240 feet. The third outflow was at Boonville to the southwest, cutting the Lansing kill gorge, with ultimate escape to the Mohawk valley. The fourth and less simple stage was controlled by westward escape around the north end of the great ridge which separates the Black valley from the east end of the Ontario basin, comprising water levels from 1200 down to the Lake Iroquois plane, about 735 feet in the Carthage-Watertown district. The complete history must include the Iroquois waters, which flooded the lower end of the Black valley.

FIRST STAGE: MOHAWK WATERS; HERKIMER LAKE

There seems to have been a stage in the waning of the ice sheet when the Ontarian lobe, pushing east over the district of Oneida lake and Rome, thrust its front, with a northwest-southeast trend, against the foothills of the southwest flank of the Adirondacks.

Plate 18



View on Alder creek moraine

One and one-half miles southeast of Alder creek. Looking west. A characteristic scene.

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The map, plate 2, shows this frontal moraine which was built along the ice margin, extending from Boonville southeast across the map.

While the ice was building this moraine the high-level waters which occupied a section of the Mohawk valley flooded the ground in front of the ice. The heavy drainage from the mountains brought down an enormous volume of detritus into the shallow waters fronting the glacier and built the extensive sand plains in the region of Forestport, having an altitude from 1440 feet down, and which apparently entirely filled the lake in that district. These delta deposits are described later (page 12).

This lake was held between the Ontarian and Hudsonian ice lobes and is believed to have outflowed through the Otisco and Unadilla valleys to Susquehanna drainage. It is described later in this paper (see page 19). The waters fell by the ice recession opening lower outlets in the Schenectady region, and the lowering was probably going on while the ice front in the Forestport-Remsen district was receding. At length the water surface fell below the divide or water-parting which bounds the Black river hydrographic area and the Black waters were differentiated as a distinct lake.

SECOND STAGE: FORESTPORT LAKE; REMSEN OUTLET

The first outflow of the distinctive Black waters was across the moraine, forming the divide, north of Remsen, and then south through the depression in which Remsen is located. The river reached standing waters and built deltas four miles south of Remsen, at Trenton and Trenton Falls. These features are shown in plate 2.

The Forestport lake with its overflow by Remsen must have persisted until the ice front had receded southwestward halfway to Rome, or to the west flanks of Quaker and South hills through a distance of over 10 miles, so as to open the Lansing kill outlet. The altitude of the lake surface was about 1240 feet during its closing phase. The altitude at the inception of the lake was as much above 1240 as was the amount of downcutting of the Remsen outlet, which was no more than perhaps 20 or 40 feet. It could not have been as much as 80 feet, as the next highest col, three miles northeast of Remsen with map altitude 1320 feet, is uncut by stream flow. We do not know where the early overflow and cutting occurred and we have no check in delta heights in the lake area, as these lie at various heights, this lake being merely the successor of the higher Mohawk waters.

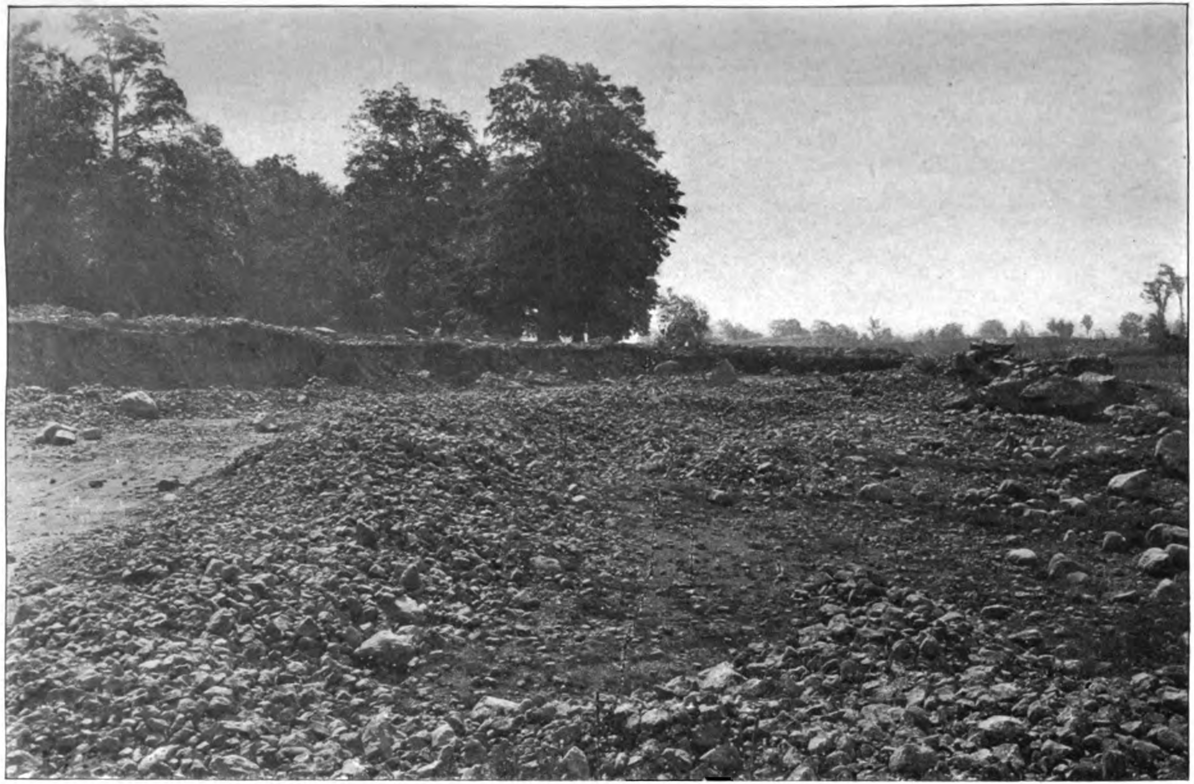
The Forestport waters were shallow and the boundaries very irregular. The abundant detritus brought into the shallow lake by the copious drainage from the southwestern Adirondacks, through the upper Black river and neighboring creeks, seems to have quite completely filled the lake, producing the broad delta plains described below.

The Remsen outlet heads in several indefinite passes among morainal knolls in the stretch four or five miles north from Remsen. By the topographic map the present altitude of these swamp cols is 1240 feet. About one mile north of Remsen the winding swampy channels unite into a single definite rock channel which continues for three miles south of Remsen and ends in terraces and scourways on the delta north of Trenton and Trenton Falls villages. The head of the rock channel north of Remsen is 1200 feet altitude. In the south edge of the village it rapidly falls to 1100 feet and in another mile it drops to 1000 feet. The fall of 200 feet in two miles gave the Remsen river a torrential character, the evidences of which are seen in the eroded limestones with abandoned cascades. These features may be well seen on the east and west road somewhat over a mile south of the village.

The flow of the distributaries over the delta northeast of Trenton and north of Trenton Falls is conspicuously shown by terraces and channels. These benchings, found specially on the slopes facing north and west, indicate that the receiving waters occupying the Mohawk valley were slowly falling during the life of the river. It also appears that the Remsen river ceased its flow while the Mohawk water was standing with an altitude of about 980 feet, the height of the lowest well-developed plains.

Forestport sand plains. The delta plains built in the Forestport and higher lakes by the tributary drainage are very extensive, covering nearly all the area for several miles north, east and southeast of the village, and must have quite filled the shallow waters. Superficially they are mostly sand and were derived from the wastage of the quartzose rocks of the Adirondack crystallines. These sand deposits were laid down over the ice-laid or moraine deposits, which in places project up through the lake beds. This is strikingly illustrated in the lofty kame hills, the most conspicuous heights of the district. The village of Forestport lies on the west side of a large kame hill. Another mass lies one and one-half miles south of the village, and a very prominent pair of steep sand hills about three miles northeast, locally called Dustin hills, rise 140 feet above the broad expanse of level sands. The ice block kettles which are such

Plate 19



Stony content of the till

Excavation one mile northwest of Alder creek. Looking southeast. The rejected material shows the stony character of the ice-laid drift in the Alder creek moraine.

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a prominent feature of the Port Leyden quadrangle (see page 15) are wanting in the Forestport sand plains.

These sand plains seem to have been built against or near the ice margin, and the materials are theoretically of triple origin: largely detritus brought in by the Adirondack drainage; partly contributed by streams pouring out of the melting glacier; and partly derived from the wave erosion of the kames and glacial deposits.

The Forestport sand plains lie in a series of sloping terraces, declining westward. Five miles northeast of Forestport, on the north edge of the Remsen sheet, the highest plain is 1400 feet, though there are evidences of wavework still higher. Other terraces or benches of the district are found at all levels down to 1140, the terrace on which the village stands. Near Enos, six miles southeast of Forestport, are sand plains at 1420 down to 1360 feet. The levels above 1300 feet must certainly belong to the first stage, or Mohawk waters, while those below 1200 feet as certainly belong to the next and lower stage, Port Leyden lake. It will not be possible to correlate all the terraces with definite attitudes of the waters, and the tilting of the land complicates the study. But this fact is brought out clearly, that the sand plains were spread out in slowly subsiding waters and were extended westward at lower and lower levels as the ice front receded.

On the map (plate 2) the delta plains credited to the several lake stages are indicated by different shadings (" conventions ") and the limits can not be exact. The altitudes of the upper and lower limits of the Forestport lake deposits are taken as about 1280 and 1200 feet. As a rule the shadings are restricted to terrace limits, but it is possible that some higher portions of sand plains marked as Forestport may belong to the earlier Herkimer lake, or that some of the lower parts may be deposits of the subsequent Port Leyden waters. However, in a general way the map must indicate the true relations.

These plains have been noted by W. J. Miller (see title 27, pages 42–45).

In the maps showing the waning of the ice sheet the Forestport lake is not indicated, but it belongs to a phase between those of plates 13 and 14.

THIRD STAGE: PORT LEYDEN LAKE; BOONVILLE OUTLET

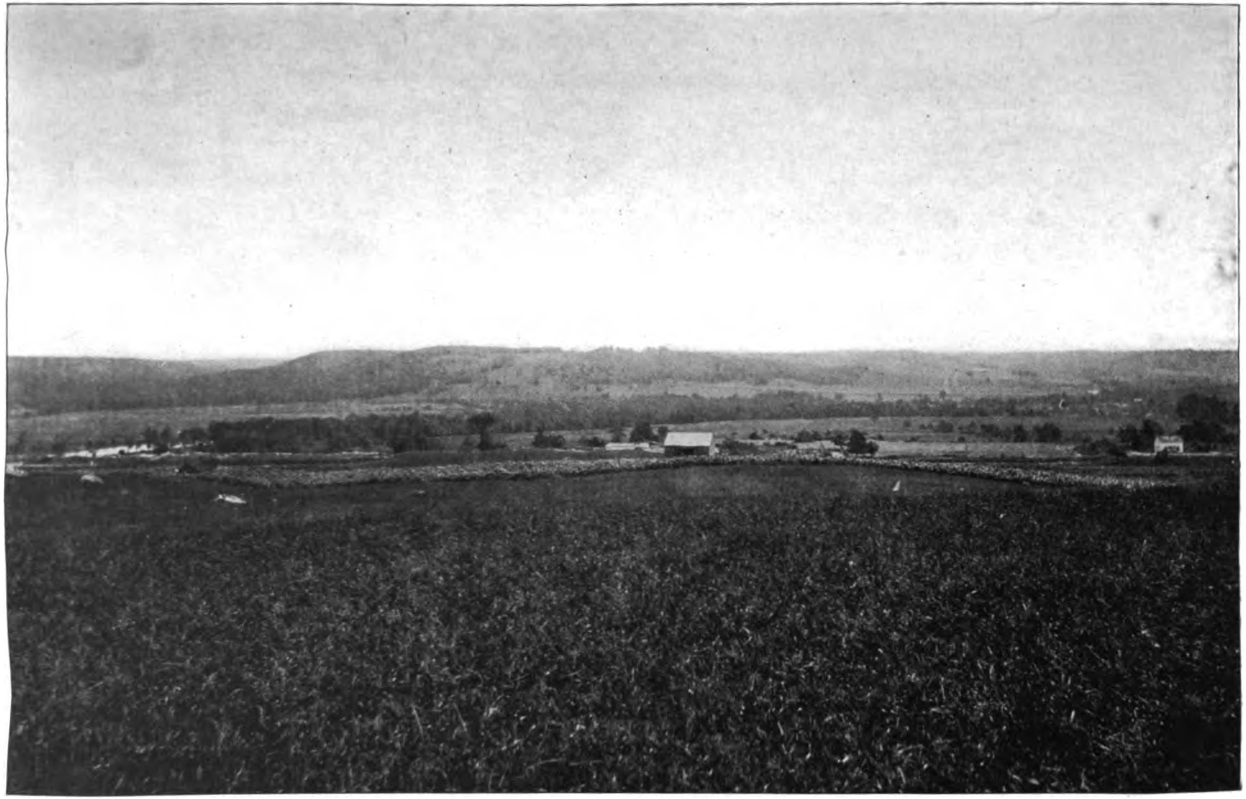
This lake is the one of longest duration in the life of the Black valley glacial waters. Its outlet was the narrow, deep gorge of the present Lansing kill, extending from Boonville south some 10 miles to the Mohawk river at Northwestern. The history of the lake is graphically indicated in plates 15 and 16 and the central part of the basin is shown in plate 3. The lake was narrow at the south end, being about two miles wide at Port Leyden, three miles at Lyons Falls, five miles at Glenfield and expanding northward. The west shore of the lake was quite direct, lying along the limestone slope, but the east shore was very irregular, being formed by the enlarging deltas built by the Adirondack drainage. The depth of the lake was about 260 feet at Port Leyden, 300 feet at Lyons Falls and 400 feet at Glenfield.

The outlet valley is a narrow, deep channel in shale, evidently cut by a vigorous stream of relatively short life, and well shown in plate 2. It does not appear just where the initial overflow began, but we know that it could not have been higher than 1240 feet, the altitude of the deserted Remsen outlet. Before the Lansing kill valley became the outlet of Black waters it must have been flooded by the Forestport lake, until the ice front receded from the Steuben valley between Trenton and Northwestern (see page 35). The ultimate head of the glacial river and the present col is a flat stretch extending southeastward from Boonville about two miles and now occupied by the summit level of the Black river canal. This has one lock (no. 71) in Boonville and the next (no. 70) over two miles south, the water surface being 1120 feet. About one and one-half miles south of the village the canal has a cut of 10 feet in limestone, which makes the present altitude of the outlet channel about 1130 feet. Immediately below the head of the channel the river had cascades, the widened main channel having narrow and steep trenches on both sides, with a plunge basin and lakelet on the east side.

One mile below the cascades the channel becomes very narrow, in shale, with only room for the present creek, the highway and the canal, and so continues for six miles. The succeeding five miles to Northwestern have a somewhat wider but yet narrow valley, and from that village the valley is open, preglacial, and partly filled with detritus. Below the village of Delta the ancient valley was blocked with moraine and the present Mohawk has been compelled to cut a channel on the east side of the old valley, locally known as the "Palisades." Delta village lies on the old lake bottom and present Mohawk flood plain.

From the channel head two miles below Boonville, to Northwestern, a distance of about 11 miles, the channel bottom drops 530 feet (from 1130 to 600), the canal having in that stretch 48 locks.

Plate 20



Sandplains in Black valley

A view of the bold front of the plain, as seen looking east across the Black valley from a point two miles east of Talcottville.

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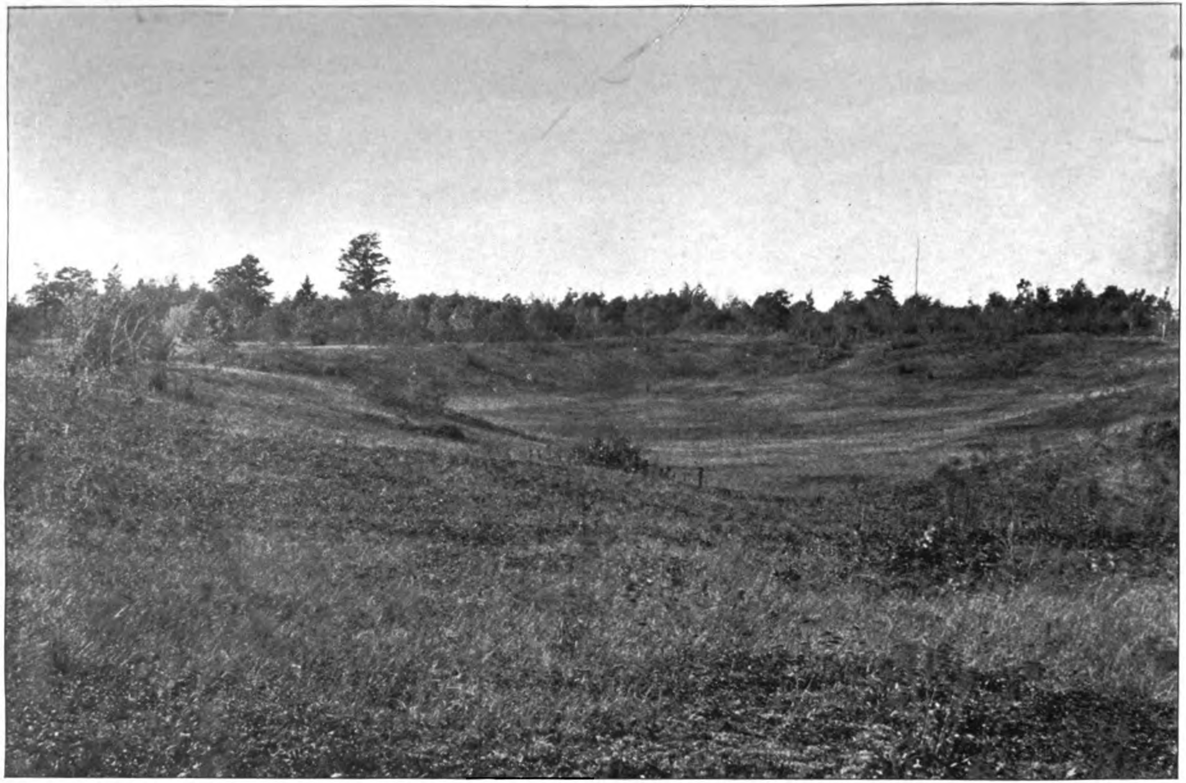
Plate 21



Kettle in Delta plain

Four miles northeast of Lyons Falls. Looking northwest from road. A small sample of the numerous basins in the sand plains.

The deltas built by the Boonville river in the falling Mohawk lakes will be discussed later (see pages 35).

The sharp hills about Boonville are kame-moraine and similar to those previously noted in the Forestport district. Sperry hill northeast of the village rises 280 feet over the village, or to 1400 feet. At present the canal is chiefly used for carrying sand from these hills to Utica and eastward cities.

Sand plains in Port Leyden lake. The east shore of this lake received an enormous supply of detritus. The deltas are developed on a magnificent scale and form a practically continuous sand plain along the east side of the valley, as shown in plates 3, 20 and 21. The plain is trenched by the Black river tributaries and broken by numerous deep, irregular basins or kettles produced by the melting of blocks of ice which had become detached from the waning glacier and surrounded, or sometimes wholly buried, by the delta sands. These ice block kettles probably surpass in size, number and excellent character any other district in the State.[1] (See plate 21.)

Some of the higher sand areas along the east edge of the Port Leyden quadrangle and eastward may perhaps have genetic relationship to local waters held along the ice margin, or possibly even held between the Black valley ice lobe and alpine glaciers from the Adirondacks, but the broad, smooth plains indicated on the map must certainly correlate with the Boonville outlet. About Bucks Corners the sand plain abuts against moraine at 1220 feet. Northeast of Port Leyden the good delta plain is 1215 to 1220; south of Brantingham it is up to 1225 to 1230 feet. Above these levels the plain becomes duny, rolling and irregular. Beyond the upper limits of the plains dune knolls are common. The northward rise of the sand plains on the Port Leyden sheet averages about five feet per mile, and as they are thought to have been deposited at about the same time this slope may be taken as the amount of the deformation.

The depth of the lake deposits must be great, as the kettles, except a few at the north edge of the map, do not hold water, though some of them are over 60 feet deep; and rock or till rarely appear except in the deeper stream cuttings. Some of the kettles show cobbly kame gravels and boulders on their walls.

The sand plains are now destitute of forest and occupied by grass and scrubby growth of scattering trees.

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[1] A good example of a large kettle in a small delta in central New York is described in Jour. Geol. 6:589.

FOURTH STAGE: GLENFIELD LAKE; COPENHAGEN-CHAMPION OUTLETS

The remarkable series of west-leading channels shown in plate 4 are the outlets of this water.

This lake did not have a permanent level but a series of falling levels as new outlets were opened on the north-facing slopes southwest of Carthage. The primitive and highest level was something over 1200 feet, the present altitude of the bottom of the highest channel, a mile northwest of Copenhagen. The lowest level was a blending into the waters of Lake Iroquois at about 740 feet. The lowest scourways seem to lie through West Carthage, a well-defined channel west of the village being 760 feet.

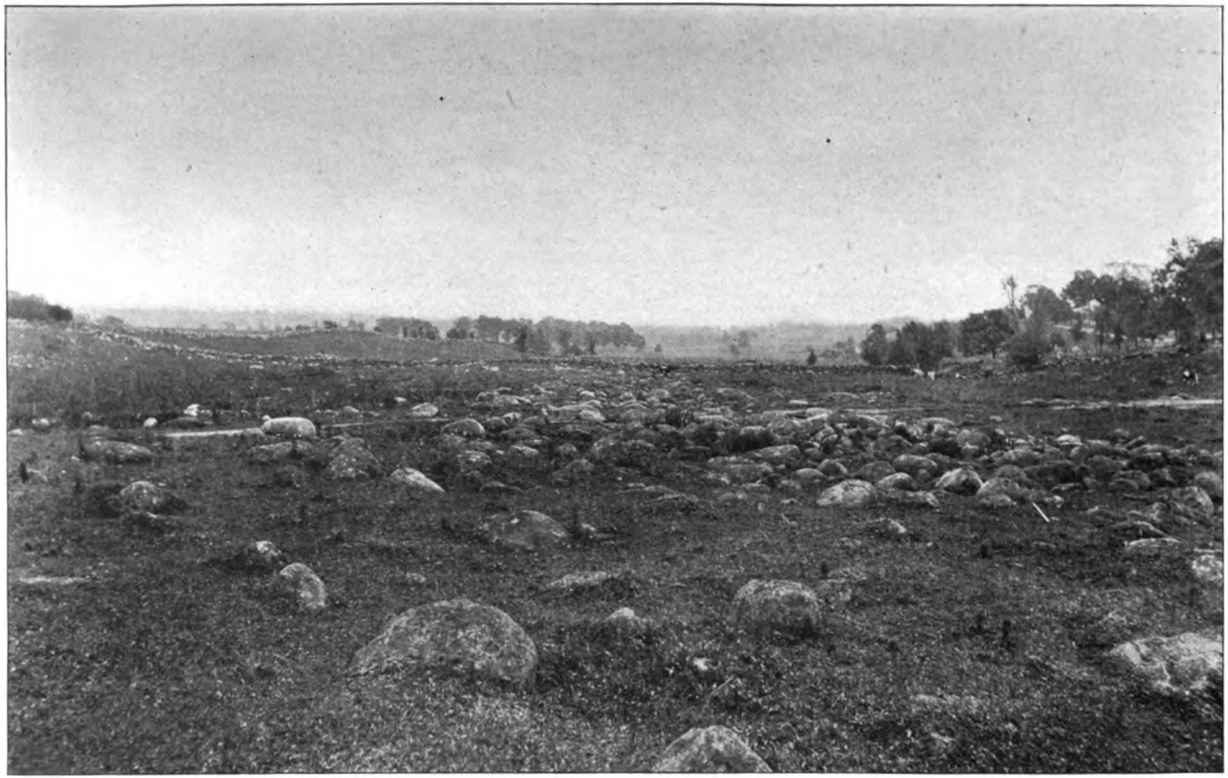
At the beginning of this stage the waters extended up the valley to Boonville, but the area diminished as the surface fell by the opening of successively lower outlets until only the lower or northern part of the valley was flooded, probably only the stretch from Carthage to Glenfield. This stage is called the Glenfield, as that village is the most northerly in the axis of the valley.

The northern part of the eastern shore of the lake is on territory not yet mapped, being the quadrangle east of the Carthage and north of the Port Leyden (Lowville sheet).

The curving course of the outlet channels shows how the ice front curved about the higher ground and deployed on the low ground, thus forcing the drainage against the convex slope. The earliest flow must have passed along the ice front east of Adams and finally reached the primitive Iroquois waters farther south, perhaps at Sand Bank or Williamstown, or possibly as far as Camden. All the subsequent drainage found its base level in Lake Iroquois at Adams, where an extensive delta was built, with altitude 620 to 630 feet and fronted by the Iroquois beach. The higher channels were cut in Lorraine shales, the lower in limestones.

When the ice front lay higher on the land slope there must have been a similar drainage past the ice margin of the local waters and such channels of the earlier time are indicated on the map, east and southeast of Adams, in the towns of Rodman and Lorraine, lying along the general slope with a southward direction. This local drainage probably ultimately reached the early Iroquois farther south; but the local drainage of a still earlier time must have followed along the ice margin until it reached the Mohawk waters in the vicinity of Rome (see page 34). No attempt is here made to fully map the high-level ice-border drainage, it being represented on plate 4 only where casually found. However, the cross-ridge

Plate 22



Glacial stream channel

One mile north of Champion and four miles west of Carthage. Looking south, upstream.

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channels, from valley to valley, and parallel with the general land slope, must occur over the west-facing and south-facing slope of the high ground as far as to the Rome district.

Deltas in Glenfield lake. During the previous stage a small lake had been held in the valley of Deer river, along the summit of the great ridge between the Black and Ontario valleys. The escape of the Deer lake must have been westward through a summit swamp, north of New Boston at about 1530 feet, into the ice-border drainage noted above. One channel seems to lie through Barnes Corners. When the ice barrier receded to the vicinity of Harrisburg the Deer lake escaped eastward and so continued by a series of small but distinct channels at falling levels until the Deer lake was drained. These outlets of Deer lake built a delta of conspicuous size on the west shore of the Black waters near Harrisburg, and five miles northwest of Lowville. Other deltas occur where the Deer river dropped its detritus in the falling Glenfield lake below High Falls and at Kings Falls. The reader should observe that the Deer lake outlets are the only east-leading channels on plate 4.

FIFTH STAGE: LAKE IROQUOIS

When the ice front receded from the promontory lying between Watertown and Carthage the distinctive Black valley waters ceased to exist and the Carthage district was occupied by the waters of the great Lake Iroquois. The Iroquois beaches are found in conspicuous form on the steep slope northeast of Watertown, at 733 feet. Eastward toward Champion Huddle and Carthage the shore line features are fragmentary, but the altitude is taken as 740 to 750 feet. The plain of the Black river above Carthage is now 730 to 740 feet, and the Iroquois waters at first probably extended some miles up the valley, but soon filled with the river silt, becoming a swamp. The real delta of the Black river in Lake Iroquois is the very extensive sand plain heading northwest of Carthage forming the " Pine Plains," which extend to Black River, Felts Mills and Leraysville. The head of the plain is about 735 feet, declining to 520 at Leraysville.

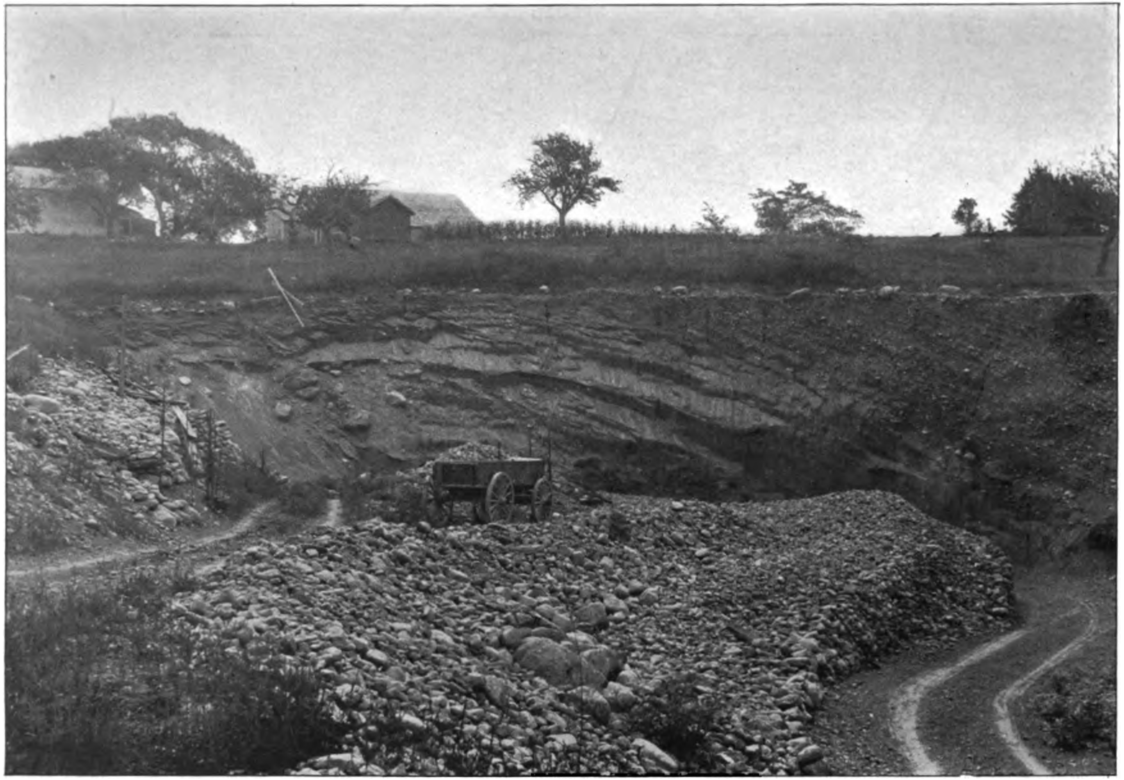
Until the quadrangle north of Carthage is mapped the Iroquois features of the region can not be satisfactorily described.

PREWISCONSIN TOPOGRAPHY

The tract of country covered by the heavy channels in plate 4 exhibits many scarps, terraces and hollows which antedated the river flow under discussion. Some of these are comparable to the scarps and benches shown in plate 3 on the west side of the Black valley. These features may be certainly attributed in part to the millions of years of weathering and stream work before there was any ice invasion. But the peculiar shaping was done in part by the eroding action of the ice sheets, and specially by the forced glacial drainage of ice sheets previous to the Wisconsin.

A good example of these anomalous features is the Rutland hollow and hill east of Watertown. Here is a capacious valley behind an isolated rock mass, both having northeast by southwest direction, transverse to the general land slope and normal drainage but consonant with the ice blockade and ice-border drainage. It seems quite certain that any earlier ice invasion must have produced, both in advance and retreat, lakes and drainage somewhat similar to those here described. The accumulating evidence of more than one glacial epoch in New York adds force to the thought that some of the peculiar relief features of the region have been produced by multiplicity of glaciation and glacial drainage. The lowland of St Lawrence valley and east of Lake Ontario exhibits many anomalous features which harmonize with this view.

Plate 23



Stream deposits in Lake Iroquois

East Watertown, mouth of Rutland hollow. Looking southeast. At the left is seen a mass of bouldery till enclosed in the sand beds.

MOHAWK VALLEY GLACIAL WATERS

FIRST STAGE: EARLY ADIRONDACK DRAINAGE

In describing the outflow of the Black valley waters reference was made (page 12) to deltas built at Trenton by the Remsen river and north of Rome by the upper Mohawk. These deltas are too massive to represent local and transient lakes held in embayments along the edge of the glacier, and their position and relation to the ice front and to the open valley forbid the assumption. The ice front here was a lobe pushing in from the west. The deltas lie on the north border of the broad Mohawk valley and were evidently deposited in broad waters which flooded the Mohawk and extended far east. The existence of other high-level lake deposits in the Mohawk valley has long been known, terraces and level stretches being conspicuous at intervals from Utica to Schenectady. The waters were ice-dammed. The Hudson valley ice lobe blocked the valley on the east while the Ontario ice lobe blocked it on the west. With the knowledge already gained concerning the positions of the receding ice fronts, the impounded waters and the inclosing topography, the conclusion is imperative not only that the Mohawk valley held glacial waters but that they were sustained at different levels.

In the waning and thinning of the ice sheet which overspread central and northern New York there must have been a stage when only a neck or strait of ice rested in the Mohawk valley, connecting the Hudsonian and Ontarian lobes of the Laurentian glacier. The earliest glacial waters of the Adirondack region must have gathered in the valleys along the southern slopes of the highlands and resting against the margin of the ice in the Mohawk valley. The only escape for these waters was southward across the Mohawk ice at its lowest point (see discussion of this matter in the introduction). The sand plains in the Adirondacks at high levels probably belong to this time. Some of the water deposits were probably accumulated in restricted waters, held by local glaciers or by tongues of the receding ice sheet which surrounded the exposed highlands; but the ultimate escape of the waters must have been to the south and over the belt of stagnant ice which lay in the Utica-Little Falls section of the valley.

The early removal of the ice sheet from the Adirondack highlands and the consequent existence of high-level glacial waters in the mountain district has been recognized by F. B. Taylor (see title 36). He noted terraces and sand plains in the Saranac valley at 1370 feet, and other water planes at 1400 to 1600 feet. For these waters he proposed the name Lake Adirondack.

As these waters must have been extremely disconnected, lying at different levels about the margin of the exposed highlands, and tributary to those on the south side with ultimate escape across the ice strait in the Mohawk valley, the writer hesitates to call them by a name implying a distinct lake. However, the name Adirondack waters holds both by priority and appropriateness.

The existence of standing waters in the larger Adirondack valleys has also been recognized by I. H. Ogilvie (see title 29), but no altitudes are given.

It is not possible now to locate with absolute confidence the point or points of outflow, or the valley south of the divide which carried southward the glacial waters. It was not necessarily by the stream which today has the lowest col on the divide between Mohawk and Susquehanna drainage, and there might have been more than one point of escape.

The col at Cassville and Richfield Junction (Delaware, Lackawanna & Western Railroad) 10 miles south of Utica, has a combination of characters that are suggestive in this connection (see plate 5). Here is a smoothed col, over a mile wide, heading at about 1260 feet the wide, smooth valley at North Bridgewater now drained by the west branch of the Unadilla river. A broad sand plain north of the railroad junction has the altitude of the col and indicates standing water north of the divide. A kame-moraine area north and west suggest a long stand of the ice margin at this place with heavy outwash. This pass could not have been the outlet of widespread or open Mohawk waters as the Cedarville pass, six miles southeast, is 40 feet lower. The writer has supposed (see title 17, page 20) that the glacial waters of the Sauquoit valley were responsible for the characters of this pass, but they hardly seem competent. The pass at Bouckville, the head of the Oriskany valley at 1150, is also suggestive, but it lies far west. Another pass which certainly carried a flood of water is the col at the head of the Otsego-Susquehanna valley with altitude 1360 (described page 23). If this outlet did not carry the earliest flow from the Adirondacks across the ice strait it certainly did carry glacial waters before the Cedarville pass was opened. It has also the location opposite what would seem to have been the weakest section of the waning ice strait.

The ice in the valley may have been so heavily burdened with rock rubbish that submergence could not lift it, but the waters must have aided the melting, and eventually a section of the valley was free of ice and held only the earliest of the Mohawk glacial lakes.

We have some facts which bear on the matter of the location of the weakest section of the Mohawk ice strait. The existence of drumlinlike forms on the south side of the valley and with east and west direction has been recognized since the publication of the Utica and Richfield Springs sheets. In 1908 Professor Brigham described west-pointing drumlins in the Johnstown region (see title 6, page 25). In the autumn of the same year the writer determined that drumlins indicating a westward flow of ice exist in perfect form in the district northeast and northwest of Richfield Springs, but that they terminate east of the Utica meridian. The ice-molded drift forms a restricted area, mostly on and south of the line of divide, about eight miles wide beginning north of Otsego lake and stretching northwest to beyond Cedarville, a distance of about 18 miles. The drumlins are partially indicated on plate 5.

It has been shown that drumlins are a product of the sliding movement of the thinning ice edge when under efficient thrustal motion of thick ice in the rear.[1] The Richfield Springs drumlins were produced by the movement of the thinner ice on the high ground, under the push of the thicker ice in the valley eastward. The more remote pressure was, of course, from the Hudson valley lobe. The drumlin-forming ice was an overflow from the valley ice tongue.

Here we have evidence of ice flow up the valley, from the Hudsonian lobe; and we have proof that for a long time subsequent the Ontarian lobe lay over the Rome district. The westward flow of the Mohawk valley ice was, at this phase, probably met by the opposing Ontarian ice somewhere in the Little Falls-Utica district. The locality of the meeting between the two ice tongues, in the later phase, would probably be the place of subsequent separation.

The question is now pertinent: Why did the Hudson ice push so far westward up the Mohawk valley, meeting the Ontario glacier much more than half way, while at a later time the Ontarian lobe lingered over Rome, at the west end of the valley, when the Hudson valley in the Schenectady district was clear of ice? The explanation seems to lie in the form and the relative altitude and cross section of the St Lawrence and the Champlain-Hudson valleys. When the ice body was thick over both the Champlain-Hudson and the St

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[1] Drumlins of Central Western New York. N. Y. State Mus. Bul. 111, p. 429.

Lawrence-Ontario the former dominated in the Mohawk region, for the reason that the course was more direct and the distance less. But as the ice body thinned this advantage was overbalanced by the narrower and more restricted cross section of the Champlain valley as compared with the open, though somewhat higher St Lawrence.

At the time of the ice retreat the north boundary of the State was depressed at least 600 feet below its present altitude and the entire Mohawk area was lower than now and probably somewhat lower relatively to central New York.

SECOND STAGE: HERKIMER LAKE

The sketch map, plate 1, shows the southern limits of the Mohawk drainage, including the Schoharie valley. The passes across the divide which bear evidence of stream flow are also indicated.

The first step in the study of the glacial lake history is to determine the altitudes of the water planes and to find the points of overflow or the correlating outlets, keeping in mind the fact of some later northward uplift. It was discovered that very extensive sand plains north and east of Forestport and near the hamlets of Grant, Gray and Ohio, in the basins of the upper Black river and of West Canada creek, had an elevation of 1440 feet, while other extensive plains ranged in the neighborhood of 1300 feet. Examination of the passes leading out of the Mohawk basin shows a strong river-cut channel in limestone at the head of the Otsego valley and seven miles east of Richfield Springs, with an altitude of about 1360 feet. Another capacious channel of perfect form lies at Cedarville, eight miles northwest of Richfield Springs, at the head of the Unadilla-Susquehanna, with an elevation of 1220 feet. Farther west is only one pass with lower altitude than the Cedarville, at Bouckville, four miles north of Hamilton, leading to the Chenango river, with an elevation of 1150 feet. Passes at Richfield Junction and at Sangerfield have elevations of 1260 and 1240 feet. All these features are shown on the Richfield Springs, Winfield, Sangerfield and Morrisville sheets, and the two passes first named are shown on plate 5. The passes on the east can have no relation to the Ohio water planes, being either too high or too low, with the exception of one four miles south of Middleburg in the Schoharie valley, at the head of the Catskill creek, with elevation 1200 feet. Examination of this col shows a tiny stream cutting across the summit but incapable of carrying a respectable creek; and the flow there was probably northward.

Taking the several elements of the problem into consideration the only pass leading out of the Mohawk basin which correlates with the widespread sand plains having an altitude of 1400 feet and upwards is the one at the head of the Otsego valley, between Springfield Center and Summit lake. A northward uplift of about two feet per mile brings this channel, 1360 feet, into close accord with the high sand plains at Forestport, Grant, Gray, Ohio and Devereaux-Stratford.

The Summit lake channel is in limestone. The map makes the divide a mile north of the lake but the cut channel is at and south of the lake. Going north from Springfield Center singular heaps and knolls of limestone rubbish are seen, which are clearly piled by plunging or cascading waters. Beyond these the channel is bare limestone in ridges and hollows with lateral recesses and terraces. North of the lake and swamp are moraine knolls at the head of the pass, at about the altitude of the lake. The aneroid and hand level made the stream-cut limestone ridges south of the lake somewhat higher than the lake. It would seem that the original rock divide must have been in the limestone south of the lake.

The morainal surface at the head of the pass and the irregular bed in the eroded limestone indicate that the river did not have length of life sufficient to level or smooth the channel entirely across the col. The head of the pass may have been ice-obstructed; and it is possible that the flow in this pass was directly from across the strait of ice which filled the valley on the north. This seems the probable locality where the early ice-bound waters, held about the exposed foothills of the Adirondacks, would find ultimate escape.

No clear separation can now be made between the Adirondack waters which were drained across the ice and the early lake in the ice-free section of the valley. As most of the features described in this chapter lie in the area of Herkimer county the name Herkimer lake may be properly given to the waters, without close discrimination as to altitude and outflow.[1]

The Summit lake channel correlates with the 1400–1440 feet sand plains, the difference of 80 feet giving the theoretical uplift of two feet per mile, with some allowance for depth of the river and downcutting of the outlet. In the same way the Cedarville channel, 1220 feet, correlates with the sand plains at or near 1300 feet. The latter are well developed contiguous to the higher plains, and represent the lower level of the Herkimer lake.

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[1] The sand plains at Forestport are in Oneida county; part of those at Devereaux-Stratford are in Fulton county; and the Summit lake outlet is just over the line in Otsego county. The Cedarville channel, which was the outlet of the positively open-valley water, is in Herkimer county.

With the opening of the Cedarville channel the Herkimer waters fell about 100 feet. The amount of downcutting is not evident, but the present channel is 140 feet lower than the Summit lake channel.

The Cedarville channel was located theoretically in advance, simply from the map.[1] Its excellent character even surpassed expectation. It is a handsome and typical river channel of mature form. It is at least one-fourth of a mile wide; steep banks, uniform width and grade, with the long stretch of level summit occupied by a swamp of cedar which has given name to the village. The valley below the col, through East Winfield, West Winfield and Unadilla Forks, has the characters produced by a strong river with low gradient.

It is possible that the Ontarian ice lobe backed away along the southern divide sufficiently to allow the Herkimer waters to find escape by the Bouckville pass, at 1150 feet, but it is not probable. A high ridge between the Unadilla and Sangerfield rivers extends north nearly to the parallel of Clinton, ending in Crow hill, six miles southwest of Utica. The ice lobe in the Utica district probably pressed against this salient to the close of Herkimer time.[2]

The Cedarville channel is believed to have been the final outlet of the Herkimer lake, and to have persisted all the time required for the ice lobe in the Hudson valley to recede sufficiently to open a lower pass in Albany county, initiating the next stage.

The extent of the Herkimer sand plains is suggested by plates 2 and 7, where they are shown ranging from 1440 down to 1280 feet. They will be found in many districts, either where heavy streams poured into the lake or where there was outwash from the glaciers. The differential uplift must be taken into account, which may not be uniform far to the north. They should be found in large development through the Adirondacks, but will not occur in strength on

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[1] The certain proof of the correctness of the glacial lake philosophy is found in the fact that nearly all the more important glacial stream channels in the State, described by the writer, have been located in advance of any visit, by the study of the topography in relation to the position of the ice front.

[2] The writer has described certain west-leading channels at Crow hill (see title 17, page 22), but they are regarded as having carried only the small volume of water from the Sauquoit valley on the east over into the Oriskany valley and Bouckville escape.

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the south side of the Mohawk valley as the streams there are relatively short and weak, the slope steep and the strata chiefly shale.

Toward the close of the stage the Herkimer waters probably extended from Utica to Johnstown. Its precise limits are unknown. Plate 13 gives suggestion of an early phase.

The evidences of standing water at high levels throughout the Mohawk basin are abundant and conclusive. Above about 1200 feet the features are chiefly the extensive sand plains by the northern drainage, but below that level the proofs are more varied and very common. Delta plains usually occur, at falling levels, along the stronger streams and in hundreds of localities where the detritus was not so abundant as to produce definite and conspicuous plains we find silted hollows and sandy stretches.

Below about 1200 feet the valley walls exhibit the peculiar smoothness or softness of outline characteristic of wave-washed slopes. Distinct beach lines are not uncommon and in some localities the horizontal marking of the slopes due to wave erosion are striking. They are specially conspicuous in the Little Falls district where the soft Utica shale of the valley walls combine with other factors to favor their production. Some of these beach lines require for visibility a viewpoint of proper altitude and a suitable lighting.

The best example noted by the writer of the high-level beach lines lies on the south side of the valley four miles southwest of Little Falls, and may be clearly seen from the New York Central and the electric railroads in all lights, but are specially prominent with a sunset lighting. They are shown in the accompanying figure and in plate 25.

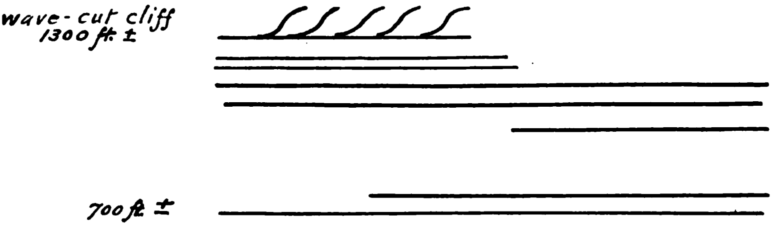


Figure 1 Sketch of beach lines produced by high-level waters in Mohawk valley, four miles southwest of Little Falls. View from river bank two miles southwest of village. Compare plate 25.

In a former paper these horizontal lines were attributed to stream work of ice-border drainage, but it is now found that they are the duct of lake waters. The highest wave-work that is evident on the ground is at about 1300 feet, a cliff and terrace at the foot of the summit knoll which was the site of the triangulation station (1372 feet). A farm house stands on the terrace by the highway which traverses the wave-cut hillside. The highest beach line of the series, shown in plate 25, is at about 1200 feet, and the lowest is at about 700 feet.

Similar conspicuous beach lines occur on the north side of the large valley, and also on both sides of the lateral valley leading southeast toward Newville. It would seem that the northwest winds were able here to produce wave and current work that was effective in carving the soft shales. Other examples of wave action occur east of Little Falls but require for clearness a higher viewpoint than the railroads.

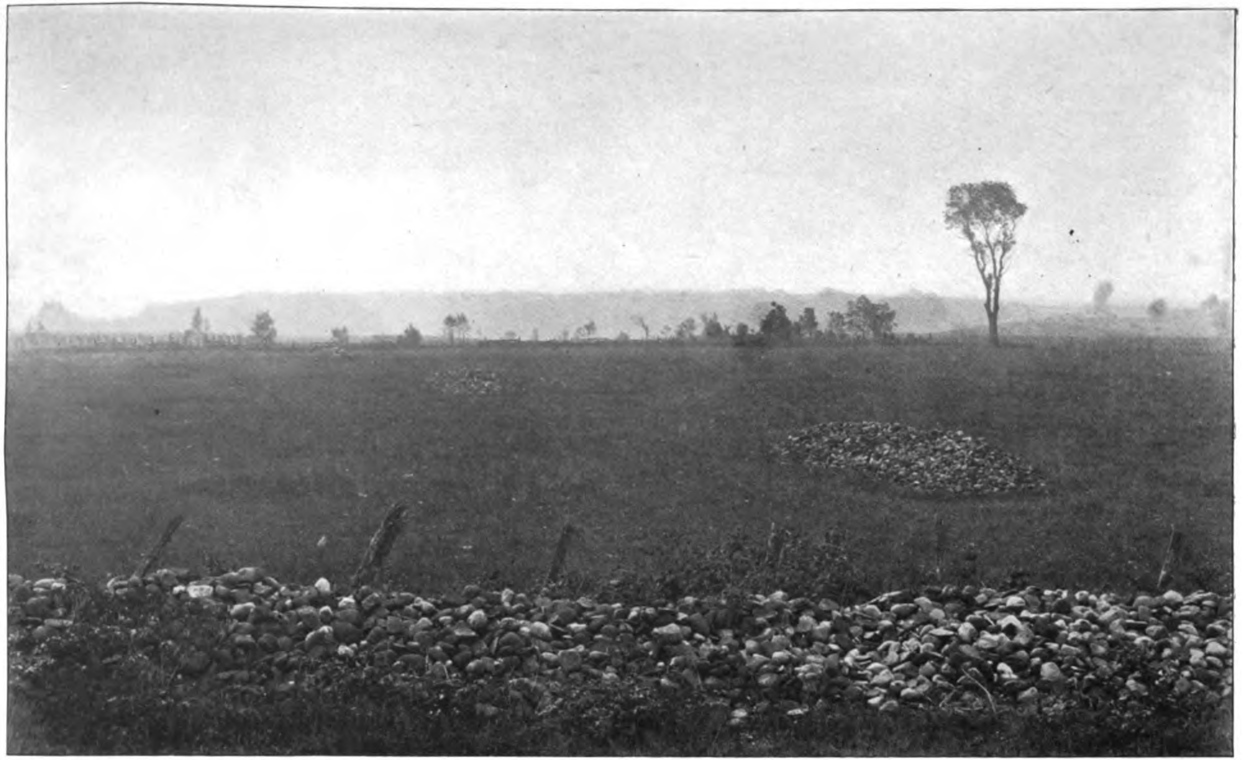
Conspicuous shore lines lie on Sperry and Park hills east of Boonville, in the neighborhood of 1200 feet.

With recognition of their nature these beach lines will be found in many localities throughout the areas of the Herkimer and the lower lakes.

THIRD STAGE: SCHOHARIE LAKE

The only large valley opening into the Mohawk from the south is the Schoharie. The river rises in the heart of the high Catskills, the three headwater cols having, by the map, 1920 feet altitude. A glance at the map, plate 1, will show how the attitude of the valley, declining northward toward the receding ice barrier, fulfilled the primary condition for a glacial lake. The valley must have held glacial waters at different levels. Some of the passes at the head of the valley might have been blocked by local or alpine glaciers during the earliest phase, but one or more of them must have been the outlet for the primitive lake. Later the narrow gorge across the west divide at 1560 feet must have become effective. From the map it would appear that the next successive outlet would be the 1200 feet pass on the east divide, four miles southeast of Middleburg, at the head of the Catskill creek. However, that does not seem to have been the order of events. The Middleburg pass never carried a large stream, and the small flow which did occur was probably northward into the Schoharie waters. This somewhat surprising fact is explained by two factors in the problem, first the postglacial deformation, and second, the larger topographic relation of the valley to the Hudson and Mohawk valleys. The Middleburg col is 25 miles south of the parallel of the Cedarville channel. If the northward uptilting of the land involved the Schoharie valley, the two feet per mile of tilt would make the Cedarville pass 30 feet

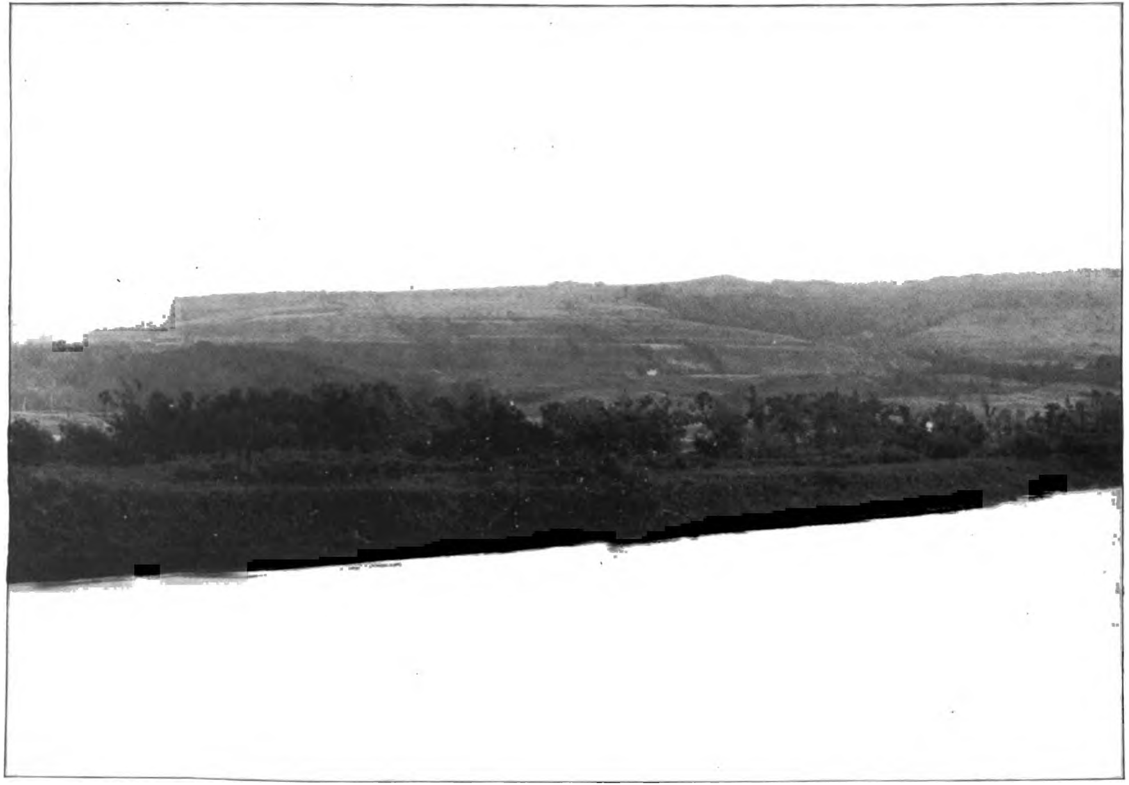
Plate 24



Cobble heaps on Delta tract

One mile southwest of Delta. Looking south from highway. Note the subuniform size and rounded forms. A characteristic view on the delta plains.

Plate 25



Beach lines in Mohawk valley

Wave-work of lake waters, south side of Mohawk valley, four miles southwest of Little Falls. Mohawk river in foreground.

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below the Middleburg, while half that slope would still keep the Middleburg plane superior. The second factor involves the ice barrier. During the earlier phases of the Schoharie lake history, when the Middleburg pass might otherwise have been effective, the Hudson valley ice tongue probably lay against the Catskill highland, west of Catskill village, at so high a level as to block outflow of the Schoharie-Mohawk waters by the Catskill valley. Later, when the ice was removed from the Catskill scarp the Cedarville outlet was probably open at an inferior level. Detailed study of the deltas built in the Schoharie valley by side streams will probably show a strong lake plane somewhat beneath the Middleburg pass, the latest phase of the Herkimer lake.

Professor Brigham has noted lake deposits in the Schoharie valley above Esperance and in the tributary Cobleskill valley, which he attributed to a morainal dam near Burtonsville, and he called the waters the Schoharie lake. The present writing would make the name include all the glacial waters which, extending through both the Schoharie and Mohawk valleys, had their escape across the east divide of the Schoharie basin. Local names may be desirable for any distinct phases of these waters.

Schoharie lake outlets. The first downdraining of the Herkimer lake and the initiation of the Schoharie came when the Hudsonian ice lobe, lying against the Helderberg scarp west of Albany, weakened so as to permit outflow across the east divide of the Schoharie valley.

The earliest outflow of the Schoharie waters was probably along the face of the Helderberg scarp, crowded between it and the glacier. Plate 6 indicates the channels along the face of Countryman hill and southward, specially under 1100 feet. The writer has not made close study of the district but sufficient to show that the saliences of the great scarp west of New Salem up to about 1200 feet have been scraped by powerful water currents. The map shows the southward continuation of these rivers, alongside the glacier, and parallel to the wall of the Hudson valley. Apart from any ponding of waters in the Mohawk basin such ice-border drainage was a positive necessity; but with the contribution of the Adirondack-Mohawk drainage added to the copious waters from the glacier melting there was a heavy concentration of flow along the margin of the ice tongue, seeking southward escape. The continuation of these channels far to the south is apparent on the topographic sheets.

It must not be thought that the Wisconsin glacial drainage is entirely responsible for these channels (transverse to the normal direction of the land drainage of the valley wall). They were made by stream-flow and ice-wear of probably more than one earlier glacial epoch, and certainly were occupied by the lateral drainage during the advance of the last ice as well as during its recession. The glacial rivers which we are considering only finished a work partly done long before.

The ice body in the Hudson valley lying over Albany and Schenectady must have pressed against the Helderberg scarp for a long period. The hypothetical relation of the ice lobe to the land configuration is suggested in the maps, plates 14, 15.

There are two passes across the divide, in Albany county, between the Schoharie and Hudson valleys which are inferior in altitude to the Çedarville outlet, but only the lower one was effective as a river channel. The col at Knox, five miles southwest of Altamont, at 1160 feet, is uncut and no evidences of stream work are found on the slopes of the valley. It appears that during the earlier and higher outflow of the Schoharie waters along the face of the Helderberg scarp the Knox and Delanson passes were submerged in the lake waters. Eventually the lake was lowered so that flow occurred through the Delanson pass; and when the Schoharie waters were finally drained down to about 900 feet the Delanson river was established. The present altitude of the channel, two miles west of Delanson, is 840 feet.

This channel is a good example of an abandoned stream bed, though not nearly so capacious and mature as the Cedarville. The outflow was reduced in volume because the ice was out of the Mohawk basin and the supply of water from the melting glacier was greatly diminished. The life of the river may not have been long, as a still lower escape was to be opened northwest of Schenectady. The earliest flow through the Delanson channel was forced southeast through the valley of the Boxen kill and the site of Altamont.

The area of the Schoharie waters was probably the whole basin of the Mohawk and its tributaries east of Utica and all of the Sacandaga valley that was free of ice. The height of the water on the Little Falls parallel began at about 1200 feet and fell to about 880 feet. On the parallel of Schoharie and Cobleskill the waterplanes will range from 1150 down to 830 feet (see plate 14).

No exhaustive study has been made of the planes and deltas of this stage, but sand plains have been noted in far-separated localities, some of which are indicated in plates 2, 7 and 8. The following delta plains are regarded as correlating with the Knox-Delanson outflow: the upper plains at Prospect and Trenton Falls (1160–980); the lower at Devereaux-Stratford (1160–1000); the higher at Northville-Edinburg (1040–940); the lower at Poland (940–820); and the terraces in the Lansing kill valley and the upper Mohawk at 1200 to 920 feet.

It will not be possible to discriminate sharply the upper and lower limits of the Schoharie waters, as the Herkimer waters fell slowly to the Schoharie and the latter to the next stage. If either of the changes had occurred suddenly and through a large vertical interval the two stages would be distinct in their deposits. However, within the extreme vertical limits as given above there is a large range of levels which must certainly correlate with the Schoharie stage.

The evidences of standing water will not be emphatic on the south side of the Mohawk valley as the steep, short slope, the shale rocks, and the weak streams are unfavorable to production and to preservation of delta deposits.

FOURTH STAGE: AMSTERDAM LAKE

The outlet channels of this stage are shown in plate 6, and the hypothetical position of the ice front in plate 15.

During the preceding stage, the Schoharie, the ice must have thrust itself against the high ground west of Schenectady, the Rotterdam salient, so as to block the direct outflow of the Mohawk valley waters by the present Mohawk, and forced the waters around through the Schoharie valley and out by the Knox and Delanson passes. In this third stage the ice front weakened on the Rotterdam salient so as to allow outflow by Rotterdam Junction and South Schenectady.

Theoretically the stream work of this stage must begin at a level below that of the Delanson channel, or 840 feet. At Pattersonville this plane might be 860 feet. Examination of the locality finds the facts in accord with the philosophy. The face of the hill three miles north of South Schenectady, forming the point of the great triangle between the Mohawk and Normanskill valleys, is strongly terraced and gullied down to 360 feet. The hollow on the northwest side of the hill contains a handsome channel at 580–600 feet. The face of the next hill shows stream work up to about 700 feet. The col between the heads of the Plotter kill and the Poentic kill is occupied by uncut moraine drift.

The general history of the ice recession in this district seems clear. The ice margin curved around the Rotterdam salient, with a lesser tongue pushing up the Mohawk gorge and a larger lobation in the low ground to the southwest. The ice seems to have pressed against the slope west of South Schenectady while it weakened northward and opened the 600 feet gap between the two hills near the Mohawk, in such manner that the col at the head of the Plotter and Poentic kills was not subjected to stream cutting.

The detritus carried by the higher flow across the Rotterdam salient must have been swept on in confined waters, around the ice lobation, through Altamont and southward to quiet waters in the Hudson valley. The detritus of the later flow seems to have contributed to the sand plains about South Schenectady, with altitude of 340 feet.

The south wall of the Mohawk at Rotterdam Junction may have been undercut and steepened by glacial flow crowded against the slope.

Area and sand plains. Plate 15 shows the hypothetic extent of the lake as mapped for its middle phase. On account of its lower altitude the Amsterdam waters formed only a relatively narrow body in the Mohawk and Schoharie valleys, especially for the later phase. In the Rome district the waters spread more widely along the receding Ontarian ice; north of Fonda and Amsterdam they reached so as to flood the Sacandaga and upper Hudson valleys, as long as the lake stood over about 760 feet, below which the Sacandaga held a tributary lake (see page 35).

Allowing for deformation the higher plane of the waters in the district of the Lansing kill and upper Mohawk should be 70 feet over the Schenectady outlet, or up to about 900 feet. On the parallel of Rome the uplift is 60 feet and the latest plane would be about 420 feet.

The delta plains built in the Amsterdam waters by tributary drainage occur widely distributed over the basin and agree with the theoretic levels. The most massive deposits are naturally found at the debouchment of the heavy streams. On West Canada creek, south of Trenton village, the sand plains are from 880 down to 740 feet, being partly contributed by drainage from the Lansing kill lake. On East Canada creek, south of Dolgeville, the plains are from 800 feet down. At Johnstown are water levels at about 700 feet. In the Sacandaga valley are excellent terraces and extensive plains, shown in plate 8. North of the village of Northville is a fine plain at 860 feet. The plains of Northville and of Sacandaga Park are 800 feet. The higher levels of the broad plains south of Northville extending five miles to the Great Vly, declining from 800 to 720, belong to the Amsterdam lake; below about 780 they belong to the Sacandaga tributary lake. All the above figures are from the map contours.

In the narrow Mohawk valley the lowest levels are the most prominent, being the accumulations of detritus by downwashing into the bottom of the valley and leveling by the later waters. These plains include all the level stretches which are so conspicuous from the railroads in the valley. Following are some of the occurrences: at Oriskany, both sides of the valley, at 520–540; Frankfort, 500; Ilion, 500; Herkimer, 520; Fonda, 420–460; Tribes Hill, 420–440; Amsterdam, 420–440; near the mouth of Schoharie creek from 420 down. The most extensive plains lie north of Rome (plate 2), built by the heavy ice-border drainage along the north side of the ice lobe, at 600 down to 460 feet.

The occurrence of the lake plains in the Sacandaga valley and the lower Mohawk have been noted by Professor Brigham, and correctly attributed to a Mohawk lake, but without determination of the outlet channel (see title 6, pages 26–28).

FIFTH STAGE: LAKE ALBANY

The name Lake Albany has been given by Professor Woodworth to the body of water held in the Hudson valley in the Albany region in which were deposited the widespread sands and clays, partly shown in plate 6. This lake and its relations are described in State Museum Bulletin 84 (see title 40), and it is not the province of the present writing seriously to discuss the Hudson-Champlain lake history. Woodworth regards the Albany waters as lying against the receding ice front northward over the Fort Edward district as far as Fort Ann, and as extending south in a narrowing strip of water probably to Kingston. He supposed that the barrier on the south was due to elevation of the lower Hudson a few hundred feet above its present level, with probably some obstruction by morainal drift in the gorge of the highlands. The final draining of the lake he suggests might have been due to the removal of the drift barrier by the greatly increased volume of water when all the overflow of the Great Lakes was turned through the Mohawk valley, in Iroquois time.

The broad plains at South Schenectady, which we may consider the head of the Albany delta plains, are 340 feet elevation. Somewhat interrupted by glacial drift the lake plane steadily declines until at South Bethlehem, near the bottom of plate 6, it is 200 feet; and at Coeymans the deposits terminate at 160 feet.

Mohawk rivers. A very long time intervened between the extinction of Lake Amsterdam, establishing free drainage through the Mohawk valley, and the beginning of the present river. That interval was the glacial flow that endured until the Laurentian ice body weakened north of the Adirondacks sufficiently to open an escape for Lake Iroquois on the international boundary,[1] across Covey hill, lower than the Rome outlet.

Two periods of the glacial flow have been discriminated by the writer; one called the Glaciomohawk, which covered the flow previous to the establishing of Lake Iroquois, and the Iromohawk, the outflow of the Iroquois waters (see title 17, p. 38). The Glaciomohawk river endured while the central New York waters passed through four stages: the later Lake Vanuxem, the free drainage succeeding Vanuxem, the restored Vanuxem and Lake Warren (see State Mus. Bul. 127, plates 37–40). It is possible that the readvance of the ice front in the Syracuse district, during Second Vanuxem and Warren time, was accompanied by contemporary advance of the Hudsonian lobe so as again to block the Mohawk and produce a second Lake Amsterdam, but it is now only conjecture.

The Iromohawk endured from the time when the ice left the Rome district to the time when it had abandoned the Ontario basin and lay against Covey hill, on the north boundary of the State.

The volume of the Glaciomohawk was always much greater than that of the present river, and for part of its life it received all the drainage of central New York from as far west as LeRoy. The Iromohawk was a larger river than the St Lawrence. It not only carried the precipitation of the St Lawrence basin but received in addition the contribution from the melting of the accumulated ice body.

Remnants of the Iromohawk flood plains in the form of low terraces occur along the valley, especially near the junction of larger tributaries. They range in altitude from 440 feet at Utica to about 380 at Amsterdam and 360 at Schenectady.

The relation of Lake Albany to the glacial Mohawk is not clear. With the recession of the ice front from Schenectady we lose the key to correlation which we possessed during the earlier history, in the relation of ice-border channels to lake planes. The capacity of the intrenched channel of the river below Schenectady seems insufficient for a river comparable to the St Lawrence. It seems probable that Lake Albany endured to the close of Iroquois time.

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[1] Science, XXVI, 399; Sept. 27, 1907. Also (title 40) N. Y. State Mus. Bul. 84, p. 161–64, pl. 25.

River gradients and deformation. The present river from Rome (420 feet) to Schenectady (210 feet) falls 210 feet in 92 miles by the line of the valley (not counting the stream meanders), which gives 2.3 feet per mile. The actual slope of the river is much less above Herkimer. At and below Schenectady the river has intrenched itself about 130 feet below the head of its ancient delta, the Lake Albany plane. The Iromohawk river must have poured its flood across the delta, now 340 feet in elevation at South Schenectady. The col at Rome is now 430 feet. From this we must deduct about 55 feet for 27 miles of northing, making 375 feet the altitude of the head of the later Iromohawk channel. This gives a fall of 35 feet in 92 miles, or a gradient of 0.38 feet per mile. The elevation of the highest wave-built bars and spits in the Iroquois basin near Rome is 460 feet (see plate 2),[1] which gives 30 feet of water over the sill of the channel head, which is a normal depth for the great river. If we allow the same depth of water at the mouth of the river, and the South Schenectady deposits are fine, indicating submergence, we have the same moderate grade as for the channel bottom. These figures accord well with the grade of large rivers and indicate that our estimate of the deformation is fairly correct.

In the comparison of channels and lake plains in central New York and the Mohawk valley we find the northward uplift to be about 2 feet per mile, perhaps a trifle more. Hence if we allow this amount of uplift on the Rome meridian there is no balance left for east and west deformation. It is positive that through central New York, from Sodus to Rome, there is no appreciable east-west tilting since Iroquois time,[2] and it seems quite certain that the uniformity extends east to the Hudson; in other words, that the isobasal lines have here approximately east and west direction.

TRIBUTARY LAKES

Besides the Black valley waters which during most of their life were tributary to the Mohawk waters, as already described, other lakes were held at high levels along the margins of the ice lobes and found escape into the Mohawk. The lakes held in the valleys between Syracuse and Utica were described in the Twenty-second

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[1] The writer is indebted to Mr F. B. Taylor for first drawing attention to these features.

[2] See N. Y. State Bul. 127, p. 55.

Report of the State Geologist for 1902 (see title 17). Similar to these waters held along the south margin of the lobe were other local waters on the north side.

The high ground between the Ontario basin and the Black valley must have emerged from the ice sheet as an island in the broad water (plate 13). When this land mass became connected with the exposed land on the southeast (plate 14), or even earlier, the land drainage and the glacial outwash passed around the periphery of the open area until it reached the Mohawk escape. The greater portion of the high area is today drained westward by the numerous branches of North Sandy and South Sandy creeks, Salmon river and lesser streams, and southward by the west and east branches of Fish creek and the Mohawk river. All this heavy drainage was blocked by the ice during the time shown in plates 14–16. Each valley must have held its lake, and these poured from one into the other across the intervalley ridges until the augmented water reached the Mohawk valley. An example of such transverse channels is indicated in plate 4, in the vicinity of Lorraine east of Adams. The fragmentary channels here noted belong to a late stage of the ice recession in the district, but similar cross-ridge channels must of necessity occur higher on the slope and of earlier time. Plate 2 shows one strong channel of the earlier drainage lying between Fish creek and the upper Mohawk. No attempt is made to map the minor channels, to do which will require close examination of large territory.

Lansing kill lake. These few channels in plate 2, between Fish creek and the Mohawk, point us to the story of a distinct lake in the upper Mohawk district. When the ice margin had the position that is shown in plate 15 it formed an east-west dam lying on Quaker and South hills. All the west and south drainage of the highland east of Ontario basin flowed along the ice edge, producing larger ponding in the two valleys of Fish creeks, and outflowing at Point Rock into the Mohawk and then into the Lansing kill lake. This was subsequent to the opening of the Remsen channel, but while the St Lawrence glacier was pushing a lobe up (south) the Black valley. It will be remembered that earlier the Lansing kill waters had been a branch of the Forestport lake, the connecting strait being the head of the Lansing kill valley, north of Potato hill. The time here recorded is that of the Port Leyden stage in the Black valley and the late Schoharie and early Amsterdam stage in the Mohawk basin. A profusion of delta terraces are found in the upper Mohawk-Lansing kill basin which fall into three categories;

a few of the highest, ranging above 1200 feet, probably represent the Forestport level, while those from 1200 down to about 900 feet belong to the Schoharie lake, which seems to have entered the basin through the Steuben valley northwest of Trenton. Below 900 feet the terraces must correlate with the Amsterdam waters, or below 830 feet (the Steuben col) with the local lake.

The ice seems to have lingered on the southwest flanks of Quaker and South hills while the Schoharie lake fell to the Amsterdam lake, and then the Lansing kill river extended itself through the Steuben valley.

When the ice weakened on the flank of Quaker hill the ponded waters of Fish creek and tributaries found their outflow through the splendid series of strong channels west and east of Lee Center; and at the same time, the ice waning on the western slope of South hill, the waters found their ultimate escape by channels at Delta, Floyd and Marcy, at 600 to 500 feet, into Mohawk waters of late Amsterdam stage. These features are shown in plate 2.

As the Port Leyden lake (Copenhagen outlet, see page 13), following the suppression of the Boonville river, was probably as late as early Iroquois time, and as the initiation of Lake Iroquois was in the Rome-Oneida district, it follows that the Lansing kill and upper Mohawk valleys held glacial waters from at least the time of Forestport lake down to initiation of Iroquois. The ice here made its most determined stand, at the head of the Mohawk valley; and the consequent production of channels and deltas make it the critical locality for correlation with similar effects of the ice barrier at the east end of the Mohawk valley.

Of the many marginal lakes, mostly small, which the ice held on the north and the south slopes of the Mohawk valley only one will be described here, though a close study will discover many interesting details of the history.

Sacandaga lake. A large lake tributary to the Mohawk waters was held in the Sacandaga and upper Hudson valleys. From its sources in the southeastern Adirondacks this river enters a broad valley at Northville and at Northampton turns northeast and joins the Hudson at Luzerne. During all the time covered by this history the Hudson drainage was blocked by the Hudsonian ice lobe and the waters of all the Adirondacks were forced into tribute to the Mohawk lakes. During the life of the Schoharie lake the ice lay across the upper Hudson somewhere in the district of Corinth, covering the area of Saratoga and Ballston, and the Schoharie waters must have flooded the territory of Johnstown, Gloversville, Northville and the canyon of the upper Hudson, so much as then existed. These waters at their lowest level must have been 840 plus 70 feet for tilting, making the water 900 feet at Northville and Corinth. The Sacandaga at Northville is now 740 feet, and the Hudson at Corinth is today only 520 feet.

When the Schoharie lake was succeeded by the Amsterdam lake the Hudson valley was still blockaded and the lake covered Northville; but when the Amsterdam water fell to about 750 feet, on the Gloversville parallel, the Sacandaga-Hudson waters became a distinct lake, with outlet southward by a pass four miles southeast of Gloversville, at 760 feet. For two miles below the col this outlet is a fair channel, but half way to Johnstown it becomes narrow, though in shale, and unsatisfactory as an outlet channel of a large lake. However, with the present conception of the events connected with the ice recession it seems positive that the Sacandaga-Hudson waters must have outflowed here into Lake Amsterdam. This tributary lake must have persisted until the recession of the ice in the Saratoga and Ballston district opened a lower escape for the Hudson waters at South Corinth. The Saratoga topographic sheet shows the pass at South Corinth, at 636 feet, leading southward to the Kayaderosseras creek. The valley of this stream shows excellently the work of a short-lived river of high gradient and large volume. Below Middlegrove and at Rock City Falls the valley walls are severely cut and heavy deposits of coarse cobble detritus lie far above the present stream. The very extensive sand plains at Ballston Spa and northward are the delta built by the glacial Hudson, debouching at above 400 feet altitude in the late Amsterdam or early Albany lake. This escape of the Hudson waters would seem to have existed as late as the close of Lake Amsterdam and the establishment of Lake Albany over the Schenectady district.

The name for this lake was given by Professor Brigham, who has briefly described the Northville deltas (see title 6, pages 26, 27). Plate 8 indicates in a general way the features of the Northville district.

THE ROCK BARRIER AT LITTLE FALLS

One questionable factor in the glacial history is the effect on the drainage and the time of the downcutting of the rock col at Little Falls.

In a former paper (see title 17, pages 22, 30–33) the writer attributed some features in the Mohawk valley above Little Falls to the ponding effect of the rock barrier, with perhaps some help

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from morainal drift and lake deposits. Later study makes that conclusion seem improbable.

The lacustrine plains and terraces in the upper Mohawk and north of Rome are now found to correlate with the glacial lakes held in the whole extent of the Mohawk valley by the Hudsonian ice lobe. While the ice lay over Rome there was drainage past its northern edge at as low elevation as 500 feet; and as early in the glacial lake history of central New York as the close of Lake Vanuxem (see title 19, page 57 and plates 37, 38) there was free eastward flow through Syracuse as low as 400 feet, present altitude. The low altitude of the Syracuse passes as compared with the Rome col, 430 feet, seems partly due to the northerly position of Rome, some 12 miles, which gives at least 25 feet of relative uplift for the Rome parallel.

In plates 15 and 16 of this paper we make the low Syracuse drainage correlate with Lakes Amsterdam and Albany. It could not have been earlier than this stage, unless in some deglaciation interval as yet unrecognized. It does not seem probable that it was later, because lying in time between this and Iroquois time in central New York is the readvance of the ice at Syracuse and the considerable period of Lake Warren and the Hyper-Iroquois waters. We must not assume too great difference between the waning of the ice fronts in the Syracuse and the Albany districts.

It does not seem possible that any considerable lowering of the hard rock barrier at Little Falls could have been accomplished by the moderate flow during merely the closing phase of the Amsterdam lake. But this seems imperative if we attribute all the cutting to that one episode of lowering waters; for when the outflow on the Rotterdam salient was under 600 feet the Little Falls pass was under Amsterdam lake water, and at what now appears to have been the end of the Amsterdam stage the pass was as low as it is now.

It is believed that the glacial phenomena in New York are not the work of a single ice invasion but the product of two or more invasions. This being conceded it follows almost certainly that the production of glacial lakes must have been repeated, and the probable outflow have been similar to the latest. In this view the large drainage channels were not wholly cut by the latest rivers. In accordance with the above it seems altogether probable that the rock barrier at Little Falls was chiefly or entirely cut by Prewisconsin drainage, and that the Glaciomohawk and Iromohawk[1] rivers had only to remove some filling of drift and do a small amount of rock cutting to produce the present pass. The rock shelves were probably cleared of drift and exposed as we now find them (title 17, plates 13–25) by wave action of Lake Amsterdam waters.

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[1] These names for the glacial river were given in 1904. See title 17, p. 38.

This fact is certain, that the Little Falls pass was cut to nearly its present depth while the ice lay over Rome, and far antedating the time when the flood from the Great Lakes poured through the valley. We are compelled to the conclusion either that the trenching was Prewisconsin or that the Mohawk drainage history connected with the Wisconsin ice retreat is much more complicated than we can now appreciate.

THE DIVIDE AT ROME

Closely connected with the problem of the rock pass at Little Falls is that of the divide at Rome. It is a singular fact that the col or divide at Rome, the place of outflow of Lake Iroquois, on which headed for many thousand years a river as large as the St Lawrence, is not rock but detritus, gravel, sand and clay. This lake and stream deposit has a large area (see plate 2) and extends down the Mohawk valley about 30 miles. Well borings at Rome (see title 5, page 190) show that the depth of these water-laid deposits is considerable, in places over 100 feet. Brigham gives the rock bottom at Rome as 320 feet, and at Little Falls 376 feet. It appears that if the valley were cleared out to the rock the Mohawk river would head at Little Falls and that a lake would occupy the ground west of that point.

It has long been recognized that in Preglacial time the drainage divide was at Little Falls (see title 8, page 362) and that the water west of Little Falls was tributary to a trunk stream in the Ontario valley. It seems probable that in the earliest flow of the Glaciomohawk the stream headed at Little Falls while the valley westward was occupied with quiet or lake waters, though it may have been filled by glacial drift. However, any waters of the narrow lake would have been soon displaced by the abundant detritus swept in by the ice drainage and West Canada river and the conditions changed from lacustrine to fluviatile. As the ice lobe melted back, westward, the detrital filling probably followed it.

The deep alluvial deposit at Rome, which now creates the divide between St Lawrence and Mohawk drainage, is the delta built by the heavy glacial drainage from the north and northwest during Lake Amsterdam time (see plates 2, 15, 16). During all the life of Lake Iroquois the detrital contribution of the upper Mohawk seems to have been sufficient to block the outflow and to establish the wasteweir or stream head at Rome. A little cutting would today divert the flow of the Mohawk westward into Wood creek.

SUMMARY OF THE MOHAWK DRAINAGE HISTORY

Stage 1. The axis of the valley was occupied by a strait of ice connecting the two ice bodies in the Hudson and Ontario valleys. The waters of the Adirondacks escaped across the ice, the overflow probably being into the Otsego-Susquehanna valley. Sand plains through the Adirondacks with elevation 1450 and upward probably correlate with this stage. See plate 12.

Stage 2. The melting of the strait of ice in the valley left a stretch of open water between the ice tongues, the Herkimer lake. The water had two successive outlets, by Summit lake pass to the Otsego-Susquehanna at 1360 feet, and by the Cedarville pass to the Unadilla-Susquehanna, at 1220 feet. Correlating sand plains of great expanse occur in the basins of the upper Mohawk, West Canada and East Canada creeks at 1440 to 1280 feet. See plates 2, 5, 7, 13. The Black valley basin was flooded by the waters of this stage, so far as relieved from the ice sheet.

Stage 3. Waning of the Hudsonian ice lobe permitted escape of the waters along the face of the Helderberg scarp, west of Albany, the later flow being across the divide between the Schoharie and Hudson valleys, at Delanson, 840 feet. Correlating sand plains exist in many localities with elevation, according to latitude, from 1200 down to 820 feet. See plates 2, 7, 8, 14. The Black valley waters were now tributary to the Schoharie lake, first through the Remsen outlets and later by the Boonville outlet, as shown in plate 2.

Stage 4. Amsterdam lake. Further recession of the Hudson valley ice lobe permitted outflow of the waters about the Rotterdam salient, west of Schenectady, at 800 down to 360 feet. See plate 6. The correlating delta plains are widely distributed, having altitude in the Rome district of 860 to 460 feet. See plates 2, 8, 15. The Black valley waters were still tributary and two other tributary lakes were the Lansing kill and the Sacandaga. See plate 8.

Stage 5. Lake Albany, confined to the Hudson valley, with outlet control southward. The Mohawk valley now had free drainage, two phases being the Glaciomohawk, previous to Iroquois time, and the Iromohawk, the overflow of Lake Iroquois.

CORRELATION OF THE ONTARIAN AND HUDSONIAN ICE LOBES

Maps of the waning ice sheet. Plates 9–17

The criteria or data for determination of the positions of the ice fronts and the construction of the maps are found in the following facts:

1 Deltas or sand plains indicate approximate heights of lake surfaces and prove that open water existed at the locality when the deposits were laid, the ice being removed.

2 Stream channels indicate approximate heights of the outflowing lake, with some allowances for depth of the rivers, and imply lower levels for the receiving waters. Streams across cols must be lake outlets.

3 A series of stream-cut channels on a land slope imply a lowering barrier, the receding ice front holding the streams to their work.

4 A channel in the bottom of a col or valley with no stream work on the wall of the valley indicates that standing or open water was lowered on the valley until flow was established across the divide.

5 The border of the glacier must have had general uniformity of height, resting like a lake or river against the land, but with some rise toward the source of supply and declining downstream.

6 In comparison of features relating to lake planes some deformation of the land must be recognized.

Contemporaneous positions of the two ice fronts, far separated in the Ontario and Hudson valleys, have been quite definitely determined in a few localities by means of criteria noted above. In the Ontario basin near the head of the Mohawk valley we find an abundance of glacio-lacustrine phenomena which must have altitude relation to the eastward escape of the same lake waters; and it is found that such eastward outflow was controlled by the glacier in the Hudson valley. When the outlet channels are along a steep slope, like those on the face of the Helderberg scarp or on the hills west of Schenectady, we may be sure of the precise position of the ice front there at the time when the imprisoned lake had corresponding altitude. At the Ontario end of the lake the positions of the ice front can be determined approximately by means of inflow channels and deltas, in their relation to the lake surface. For example, the deltas at Trenton and Trenton Falls indicate subsiding lake waters, and the correlating outlets can be nowhere except through the Delanson hollow and on the face of the Helderberg scarp, where the ice-compelled rivers have left their unmistakable tracks. At Lee Center, northwest of Rome, and eastward are sluggish-flow channels at declining levels, made along the stagnant ice margin, while the lake levels were controlled by the ice front on the Rotterdam salient.

From localities of known position for the ice margin the latter can be extended theoretically, lapping on the land at levels slowly rising northward and falling southward.

Between known positions of the ice at different periods the location for time intermediate can be approximately interpolated.

The maps (plates 9–17) are an attempt to portray several stages in the recession of the latest ice sheet. A continuous waning of the glacial lobes is suggested by the maps. However, the ice sheet did not pass away by continuous and steady recession but by oscillations, readvances and reretreats; and some of the readvances may have covered considerable territory and have seriously changed the drainage. At present our knowledge of these elusive changes in the glaciers in the Mohawk-Hudson region is almost nothing and no account can be taken of them.

The maps make no claim to accuracy, except at a few points for a few stages in the history. They are only suggestive and intended to give in a graphic way the broad facts in the general history. The positions of the ice limits as indicated in the maps are separated by long periods of time, perhaps in some cases thousands of years, during which oscillations of large extent may have occurred. The positions of the ice fronts at both ends of the Mohawk valley are definite for the phases shown in plates 14–16.

These maps are an extension and correction of plates 34–42 of the preceding paper (N. Y. State Museum Bulletin 127) on Central New York drainage.

Between the stages depicted in plates 16 and 17 is a very long interval unmapped. During this time central New York had a varied lake history, including at least the Second Vanuxem, Warren and Hyper-Iroquois waters. If the ice in the Hudson advanced in sympathy with that in the Syracuse district it may have again blocked the Mohawk valley. But with the beginning of Lake Albany we have no means, now recognized, of comparing the limits of the ice in the Hudson valley with those in the Ontario. Rather than depict stages between those of plates 16 and 17 in a purely hypothetical way, they are omitted. In plate 17 the limits of the Champlainic ice lobe is a matter of conjecture.

It is only hoped that these maps will serve as suggestion and stimulus to more detailed study of the glacial phenomena, and that the future student may be able to translate much more of the wonderful history.

BIBLIOGRAPHY

The literature on the Pleistocene of the Black and Mohawk valleys is scanty, the only comprehensive paper being one by Professor Brigham (title 4). Most of the geologic work in the areas of the Black, Mohawk and Schoharie valleys has been concerned with the stratigraphy and paleontology.

The following list includes writings which have some reference to the physiography, surficial geology and Pleistocene history of the region. Papers that discuss only the stratigraphy or paleontology of the region are not included.

A list of papers relating to the region adjacent on the west may be found in the latest paper by the writer (title 19) and an extended list bearing on the Pleistocene of New York and the Champlain-Hudson district in particular is contained in Professor Woodworth's paper on the Champlain and Hudson valleys (title 40).

For convenience of reference in the preceding text; the titles are given numerical order, the arrangment being alphabetic by authors.

1 **Baldwin, S. P.** Pleistocene History of the Champlain Valley. Amer. Geol. 1894. 13:170-84.

2 **Brigham, A. P.** The Geology of Oneida County, N. Y. Oneida Hist. Soc. Trans. 1887-89. p. 102-18.

3 ——— Drift Boulders between the Mohawk and Susquehanna Rivers. Amer. Jour. Sci. Ser. 3. 1895. 49:213-28.

4 ——— Glacial Flood Deposits in Chenango Valley (N. Y.). Bul. Geol. Soc. of Amer. 1897. 8:17-30.

5 ——— Topography and Glacial Deposits of Mohawk Valley. Bul. Geol. Soc. of Amer. 1898. 9:183-210.

6 ——— Report of Field Work and Summary of Results (no title). Fourth An. Rep't Director of Science, N. Y. State Mus. Bul. 121, 1908. p. 21-31.

7 **Chadwick, G. H.** Glacial Lakes of the Catskill Valley. Science 1910. 32:27, 28.

8 **Chamberlin, T. C.** Terminal Moraine of the Second Glacial Epoch. U. S. G. S. Third An. Rep't 1883. p. 351-60.

9 **Cushing, H. P.** Geology of the Vicinity of Little Falls, Herkimer County. N. Y. State Mus. Bul. 77. 1905.

10 **Dana, J. D.** On the Existence of a Mohawk Valley Glacier, etc. Amer. Jour. Sci. 1863. 35:243-49.

11 **Darton, N. H.** A Preliminary Description of the Faulted Region of Herkimer, etc. Fourteenth An. Rep't N. Y. State Geologist. 1897. p. 33-53.

12 **Dwight, Timothy.** Travels in New England and New York. New Haven. 1822. p. 33-128.

13 **Eaton, Amos.** Geological and Agricultural Survey of the District Adjoining the Erie Canal. Albany. 1824.

14 **Eights, J.** Post-Tertiary of the Vicinity of Albany. Albany Inst. Trans. 1852. 2:335-53.

15 **Emmons, Ebenezer.** Geol. N. Y., Second District. Albany. 1842. p. 335–417.

16 **Fairchild, H. L.** Latest and Lowest Pre-Iroquois Channels Between Syracuse and Rome. N. Y. State Geologist. Twenty-first An. Rep't 1903. p. 32–47.

17 ——— Glacial Waters from Oneida to Little Falls. N. Y. State Geologist. Twenty-second An. Rep't 1904. p. 17–41.

18 ——— Geology of the Black River Valley. Carthage Tribune. Carthage, N. Y. Aug. 17, 1907.

19 ———Glacial Waters in Central New York. N. Y. State Mus. Bul. 127. 1909.

20 ——— Glacial Waters West and South of the Adirondacks. Science. April 16, 1909. 29:627.

21 ——— Correlation of the Hudsonian and the Ontarian Glacier Lobes. Science. April 16, 1909. 29:627.

22 **Gilbert, G. K.** Comments on paper by J. W. Spencer (no. 33). Geol. Soc. Amer. Bul. 1892. 3:492–93.

23 **Grabau, A. W.** Guide to the Geology and Paleontology of the Schoharie Valley, etc. N. Y. State Mus. Bul. 92. 1906. p. 333–52.

24 **Harris, T. W.** The Kames of the Oriskany Valley. Amer. Geol. 1894. 13:384–90.

25 **Hough, F. B.** Observations on the Geology of Lewis County. N. Y. Amer. Quar. Jour. Agr. and Sci. 1847. 5:324–26.

26 **Mather, W. W.** Geol. N. Y., First District. Albany. 1843.

27 **Miller, W. J.** Geology of the Remsen Quadrangle. N. Y. State Mus. Bul. 126. 1909.

28 ——— Pleistocene Geology of the Southwestern Slope of the Adirondacks. Science. April 16, 1909. 29:627.

29 **Ogilvie, I. H.** On Glacial Phenomena in the Adirondacks, etc. Jour. Geol. 1901. 10:397–412.

30 **Peet, C. E.** Glacial and Postglacial History of the Hudson and Champlain Valleys. Jour. Geol. 1904. 12:415–69; 617–60.

31 **Rich, J. L.** Local Glaciation in the Catskill Mountains. Jour. Geol. 1906. 14:113–21.

32 **Smock, J. C.** Evidences of Local Glaciers in the Catskill Mountain Region (abstract). Amer. Assoc. Adv. Sci. Proc. 1885. 33:403–4.

33 **Spencer, J. W.** Channels Over Divides Not Evidence per se of Glacial Lake. Geol. Soc. Amer. Bul. 1892. 3:491–92.

34 **Tarr, R. S.** Physical Geography of New York State. New York. 1902.

35 **Taylor, F. B.** Deltas of the Mohawk. Amer. Geol. 1892. 9:344–45.

36 ——— Lake Adirondack. Amer. Geol. 1897. 19:392–96.

37 **Upham, Warren.** Late Glacial or Champlain Subsidence and Re-elevation of the St Lawrence River Basin. Am. Jour. Sci. Ser. 3. 1895. 49:1–18; Geol. & Nat. Hist. Surv. of Minn. Twenty-third An. Rep't 1895. p. 173–81.

38 ——— Deltas of the Hudson and Mohawk Valleys. Amer. Geol. 1897. 9:410–11.

39 **Vanuxem, L.** Geol. N. Y., Third District. Albany. 1842.

40 **Woodworth, J. B.** Ancient Water Levels of the Champlain and Hudson Valleys. N. Y. State Mus. Bul. 84. 1905.

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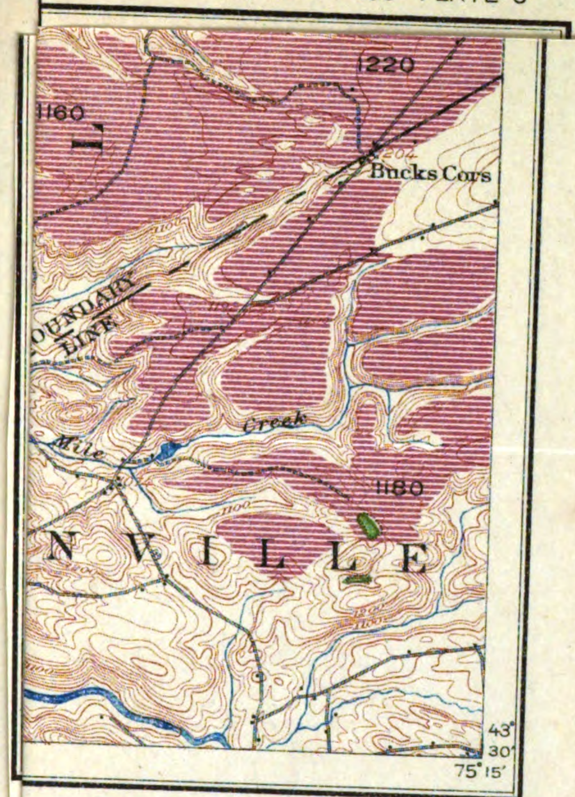
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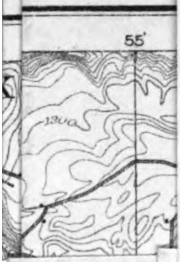

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New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 161

THE MINING AND QUARRY INDUSTRY

OF

NEW YORK STATE

REPORT OF OPERATIONS AND PRODUCTION DURING 1911

BY

D. H. NEWLAND

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Dr Augustus S. Downing
Acting Commissioner of Education

SIR: I beg to transmit to you herewith the manuscript of our annual report on *The Mining and Quarry Industry of New York State,* covering the operations and production of the year 1911, and to recommend this for publication as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

STATE OF NEW YORK
EDUCATION DEPARTMENT
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Approved for publication this 14th day of June 1912

Augustus S. Downing
Acting Commissioner of Education

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New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 161

THE MINING AND QUARRY INDUSTRY
OF
NEW YORK STATE

REPORT OF OPERATIONS AND PRODUCTION DURING 1911

BY

D. H. NEWLAND

INTRODUCTION

The mineral industries of the State shared the general dulness and reaction which marked the prevailing course of business operations during 1911. Very few branches showed progress as measured in terms of production figures. The period of short-lived prosperity experienced in the preceding year left a condition of overextension in its wake and necessarily caused a more or less radical curtailment of activity during the past season. That the setback is of no serious import to the development of the industries seems certain; in fact the current trend indicates an improvement which if continued should soon reestablish them on the former basis.

The census of production now completed for 1911 shows that the value of the materials taken from the mines and quarries in that year amounted to $31,573,111. As in the preceding year the total reached $35,400,257, a decrease of a little over 10 per cent is indicated for the industries in general.

The figures are based on some 30 different substances in crude or first marketable forms, but can not be considered as representing the full share which the mineral industries have in the business activities of the State. They are serviceable, however, for standards to compare the conditions in these fundamental branches so closely allied with many other industries of chemical, metallurgical and manufacturing nature. It may be noted that the product of iron by the blast furnaces situated within the State alone is nearly equal in value to the output of crude ores and minerals on which the above totals are based.

The iron mines are among the first to feel the effects of market changes, and their contribution last year fell off considerably in response to the decreased demand and lower prices. The gross output was 1,258,873 long tons, as compared with 1,517,880 long tons in 1910. After allowance for concentration of the low-grade magnetic ores there remained for furnace use a total of 952,364 tons, which had a value of $3,184,057. The corresponding figures for 1910 were 1,159,067 tons valued at $3,906,478. The greater part of the product as usual came from the Adirondacks where are some of the largest mines in the East. Altogether there were 11 companies who reported a production, 2 less than in 1910.

The clay-working industries made an output valued at $9,751,659. This also represented a large decrease as compared with the return for the preceding year when the value amounted to $11,518,982. The loss was mainly in the branch that manufactures structural materials such as brick, building tile, terra cotta, fireproofing etc. for which the market was uniformly depressed in regard to both demand and prices. The output of these materials was valued at $6,473,857, against $8,067,098 in the preceding year. The number of brick for building purposes made in 1911 was 1,078,019 thousands, as compared with 1,404,345 thousands in 1910, of which the plants in the Hudson river region contributed about three-fourths. The value of the articles of pottery on the other hand showed a gain and reached the highest total — $2,196,054 against $2,136,518 in 1910 — ever recorded in the State. The number of firms and individuals engaged in the different departments of the clay-working industry last year was 189.

The lessened activity in the building trades also affected adversely the quarry industries which reported an aggregate value of $5,455,312 for their products, as compared with $6,193,252 in 1910. The total was divided acccording to various uses into building stone $632, 085; monumental stone $90,468; curb and flagstone $443,036; crushed stone $2,928,740; other uses $1,360,983. The output of slate, millstones and limestone used in making hydraulic cement is not included in these totals. All kinds of stone were quarried less extensively last year, though the falling off was particularly noticeable in granite, sandstone and marble which are used largely for structural purposes. The production of limestone and trap showed little change from the totals recorded in 1910.

For cement manufacturers the year was very unsatisfactory in that it witnessed the lowest prices known to the trade. That the output in the State should have been well maintained in the circumstances testified to the sound basis on which the local industry has been established. The aggregate production amounted to 3,691,373 barrels, as compared with 3,657,015 barrels in 1910. Portland cement constituted the main part of the total, in actual figures 3,416,400 barrels valued at $2,930,434. The natural cement mills contributed only 274,973 barrels, with a value of $134,900. Eleven plants in all were active, or 1 less than in 1910.

The production of salt from the mines and wells of the State amounted to 10,082,656 barrels, a little under the total of 10,270,273 barrels in 1910, but larger than that of any other year. The value of the output was $2,191,485. Rock salt was obtained from 2 mines in Livingston county, the other producers to the number of 28 obtaining salt from brine wells situated in Onondaga, Livingston, Schuyler, Wyoming, Genesee and Tompkins counties.

Gypsum, a material used principally for the manufacture of plaster of paris and wall plaster, is the basis of a large industry which has developed practically in the last 10 years. It is found in a belt which extends from Madison county on the east to Erie county, associated with the same rocks that yield the rock salt. The output last year, mainly by underground mines, was 446,794 short tons and the value of the marketed products totalled $1,092,598. In the year 1910 the output was reported as 465,591 tons with a value of $1,122,952.

The combined value of petroleum and natural gas, the only representatives of the class of mineral fuels obtained in the State, amounted last year to $2,745,945, against $2,869,893 in 1910. The decline in value was due to the smaller prices secured for petroleum, which more than counterbalanced an increased production of natural gas. The total quantity of oil produced was 915,314 barrels valued at $1,198,868, as compared with 1,073,650 barrels with a value of $1,458,194 in 1910. The gas production was 5,127,571,000 cubic feet with a value of $1,547,077 against 4,815,643,000 cubic feet valued at $1,411,699 in the preceding year.

Among the smaller industries in which local enterprise has a prominent share may be mentioned those of talc, garnet, graphite, and pyrite. The talc is mainly produced from a single district in St Lawrence county, which enjoys a practical monopoly of the trade in fibrous talc. The production last year amounted to 65,000 short tons valued at $552,500, or about the same as in 1910. Garnet for abrasive uses is obtained in Essex and Warren counties, and the quantity reported for last year was 4285 short tons with a value of $121,759. The graphite, all of it the more valuable crystalline variety, amounted to 2,510,000 pounds valued at $137,750, a little under the previous year's total. Pyrite for acid manufacture was produced to the extent of 53,453 long tons valued at $251,466.

The remaining mineral materials which had a place in the list of products for last year were apatite, carbon dioxid, clay, diatomaceous earth, emery, feldspar, marl, millstones, metallic paint, mineral waters, slate pigment, quartz, slate, sand, sand-lime brick and zinc ore. The collected value of these materials was $3,052,143, against $3,579,488 in 1910.

It is worthy of record that a new industry so far as concerns New York State came into existence during the year with the shipment of zinc ore from St Lawrence county, where some promising developments have been in progress.

Mineral production of New York in 1910

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement	Barrels	3 364 255	$2 939 818
Natural rock cement	Barrels	292 760	147 202
Building brick	Thousands	1 404 345	6 683 071
Pottery	....	....	2 136 518
Other clay products	....	....	2 699 393
Crude clay	Short tons	6 005	9 667
Emery	Short tons	978	11 736
Feldspar and quartz	Short tons	18 012	64 503
Garnet	Short tons	5 297	151 700
Graphite	Pounds	2 619 000	160 700
Gypsum	Short tons	465 591	1 122 952
Iron ore	Long tons	1 159 067	3 906 478
Millstones	....	....	6 613
Metallic paint	Short tons	8 063	70 841
Slate pigment	Short tons	1 400	10 900
Mineral waters	Gallons	8 432 672	675 034
Natural gas	1000 cubic feet	4 815 643	1 411 699
Petroleum	Barrels	1 073 650	1 458 194
Pyrite	Long tons	37 270	175 791
Salt	Barrels	10 270 273	2 258 292
Sand and gravel	....	....	2 129 708
Sand-lime brick	Thousands	14 053	82 619
Roofing slate	Squares	14 107	79 857
Slate manufactures	....	....	3 233
Granite	....	....	244 763
Limestone	....	....	3 245 807
Marble	....	....	341 880
Sandstone	....	....	1 451 796
Trap	....	....	909 006
Talc	Short tons	65 000	552 500
Other materials [1]	....	....	258 986
Total value	....	....	$35 400 257

[1] Includes apatite, carbon dioxid, diatomaceous earth, marl and lead ore.

Mineral production of New York in 1911

PRODUCT	UNIT OF MEASUREMENT	QUANTITY	VALUE
Portland cement	Barrels	3 416 400	$2 930 434
Natural rock cement	Barrels	274 973	134 900
Building brick	Thousands	1 078 019	5 443 303
Pottery			2 196 054
Other clay products			2 083 405
Crude clay	Short tons	14 193	11 982
Emery	Short tons	769	8 810
Feldspar and quartz	Short tons	21 802	75 719
Garnet	Short tons	4 285	121 759
Graphite	Pounds	2 510 000	137 750
Gypsum	Short tons	446 794	1 092 598
Iron ore	Long tons	952 364	3 184 057
Millstones			13 177
Metallic paint	Short tons	7 237	68 870
Slate pigment	Short tons	1 646	12 864
Mineral waters	Gallons	8 923 628	756 147
Natural gas	1000 cubic feet	5 127 571	1 547 077
Petroleum	Barrels	915 314	1 198 868
Pyrite	Long tons	53 453	251 466
Salt	Barrels	10 082 656	2 191 485
Sand and gravel			1 727 367
Sand-lime brick	Thousands	15 178	92 064
Roofing slate	Squares	11 273	52 311
Slate manufactures			Nil
Granite			148 633
Limestone			3 174 161
Marble			278 041
Sandstone			955 063
Trap			899 414
Talc	Short tons	65 000	552 500
Other materials [1]			232 832
Total value			$31 573 111

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[1] Includes apatite, carbon dioxid, diatomaceous earth, marl and zinc ore.

CEMENT

The cement trade in 1911 showed a continuance of the conditions which were noted in the review for the preceding year. Prices were on the same low level, in fact averaging somewhat less than in 1910, but as the demand remained active most manufacturers were able to maintain operations at about the normal rate and thus to secure the greatest economy in production. The local market for cement has been very large owing to the unusual amount of engineering work in the way of public improvements that have been in progress in the State.

The steady decline in the prices that has lasted now for several years has subjected the cement mills to a severe test of efficiency. Some of the mills which were not advantageously situated for economic manufacture or were inadequately financed have been forced out of business. As a consequence the number of producers has fallen off from year to year, though this loss, so far as the portland cement business is concerned, has been more than made good by enlarging the capacity of other plants and by the erection of one or two new mills. In the natural cement branch the effect of the adverse conditions has been very noticeable in the output which has shrunk to a mere fraction of the former quota. The Rosendale district of Ulster county was represented last year by a single producer.

The aggregate output of cement for the year amounted to 3,691,373 barrels, as compared with 3,657,015 barrels in 1910 and 2,610,383 barrels in 1909. The production last year has not been exceeded since 1906. The returns showed that 11 plants were active, or 1 less than in 1910. In 1905 there were 21 cement mills in operation.

As shown in the accompanying table the portland cement mills contributed a total of 3,416,400 barrels valued at $2,930,434, a slight increase over the 1910 figures which were 3,364,255 barrels valued at $2,939,818. The average value of the product was 85.8 cents a barrel, against 87.4 cents in 1910. Seven plants were reported as active, 1 less than in the previous year.

The output of natural cement amounted to 274,973 barrels valued at $134,900, the greater part contributed by the single producer in Ulster county. The total for 1910 was 292, 760 barrels with a value of $147,202. In addition to Ulster county there was a small output in Onondaga county by 3 companies. Erie county, formerly a large producer, was not represented.

Production of cement in New York

YEAR	PORTLAND CEMENT		NATURAL CEMENT	
	Barrels	Value	Barrels	Value
1891	87 000	$190 250	3 931 306	$3 046 279
1892	124 000	279 000	3 780 687	3 074 781
1893	137 096	287 725	3 597 758	2 805 387
1894	117 275	205 231	3 446 330	1 974 463
1895	159 320	278 810	3 939 727	2 285 094
1896	260 787	443 175	4 181 918	2 423 891
1897	394 398	690 179	4 259 186	2 123 771
1898	554 358	970 126	4 157 917	2 065 658
1899	472 386	708 579	4 689 167	2 813 500
1900	465 832	582 290	3 409 085	2 045 451
1901	617 228	617 228	2 234 131	1 117 066
1902	1 156 807	1 521 553	3 577 340	2 135 036
1903	1 602 946	2 031 310	2 417 137	1 510 529
1904	1 377 302	1 245 778	1 881 630	1 207 883
1905	2 117 822	2 046 864	2 257 698	1 590 689
1906	2 423 374	2 766 488	1 691 565	1 184 211
1907	2 108 450	2 214 090	1 137 279	757 730
1908	1 988 874	1 813 622	623 588	441 136
1909	2 061 019	1 761 297	549 364	361 605
1910	3 364 255	2 939 818	292 760	147 202
1911	3 416 400	2 930 434	274 973	134 900

The one new producer added to the list during the year was the Knickerbocker Portland Cement Co., which began operation in the summer at its plant near Greenport, Columbia county. The mill is equipped with three rotary kilns, each 10 by 175 feet, and under full headway is expected to turn out 3000 barrels a day. The limestone quarries are situated on Becraft mountain close by and in proximity to those of the New York-New England Company, in an outlier of the Coeymans and Manlius formations. The clay is obtained locally.

CLAY

The clay-working industries rank first in the value of annual output among the mineral industries of the State. Their prominence is chiefly due to the widely distributed deposits of common clays suited for building brick, drain tile and materials of that class and the very extensive local markets for such articles. As the whole area of New York lies within the zone of Pleistocene glaciation, residual clays are of rare occurrence and of little commercial importance.

Most of the clays that are utilized are modified glacial deposits.

They are commonly of blue color, weathering to yellow at the surface, and contain rather high percentages of iron and fluxing ingredients. Extensive deposits occur in the Hudson and Champlain valleys where they form terraces at different elevations, from near water level to several hundred feet above, and also in some of the large valleys in the interior of the State. These clays generally burn at a relatively low temperature to a red color.

Deposits of white-burning and refractory clays are restricted to Long Island and Staten Island. They belong to the Cretaceous, and occur as scattered, but in some places heavy, beds. They are adapted for fire brick, stoneware, terra cotta and the better grades of building brick.

The single example of any considerable accumulation of residual kaolin that has come to notice is found near Shenandoah, Dutchess county. The property known as Fowler's kaolin mine has produced small amounts of white but rather quartzose material which has found use as stove cement. It appears to be a disintegration product of pegmatite formed in place and by some chance has escaped the general erosion.

The use of shale which is abundant in many of the stratified rock formations has been of increasing importance of late years. The principal beds are found in the Devonic, Hamilton, Portage and Chemung groups. They are worked mainly in the western counties for the manufacture of paving brick, tile and pressed building brick.

PRODUCTION OF CLAY MATERIALS

Details of the production of clay materials in New York State during the last two or three years are given in the accompanying tables which are based on reports from practically every producer in the several branches of the industry.

The general condition of the industry during 1911 can hardly be described as prosperous. Building operations in most of the larger cities were on a scale below the average of recent years and consequently the market for clay structural materials showed little activity. The Hudson river brick industry made relatively the poorest record of any branch, owing to the fact that the yards had to carry over a very heavy stock from the previous year; on the other hand it benefited by a slight increase of the prices in the New York market. The pottery trade fared better than most lines, and the production was well maintained.

The output of clay materials of all kinds in 1911 was valued at $9,751,659. Compared with the total for the preceding year, which was $11,518,982, it represented a falling off of about 15 per cent. The number of firms or individuals engaged in the clay-working industry was 189 against 223 in 1910, and the product was distributed among 39 of the 61 counties of the State.

Production of clay materials

MATERIAL	1909	1910	1911
Common brick	$8 009 766	$6 563 212	$5 310 511
Front brick	149 330	119 859	132 792
Vitrified paving brick	207 970	333 511	307 529
Fire brick and stove lining	486 894	464 693	413 500
Drain tile	268 589	254 679	202 292
Sewer pipe	117 324	127 731	138 258
Terra cotta	962 497	1 062 017	718 700
Fireproofing	166 025	256 820	229 627
Building tile	54 397	65 190	82 217
Miscellaneous	101 497	134 752	20 179
Pottery	1 827 193	2 136 518	2 196 054
Total	$12 351 482	$11 518 982	$9 751 659

A comparison of the items entering into the production shows that the main part of the decrease came from building brick, the output of which was valued at $5,443,303 against $6,683,071 in 1910, a decline of $1,239,768. Common brick accounted for $5,310,511 in the totals against $6,563,212 in the preceding year, and front brick for $132,792 against $119,859. The vitrified paving brick industry showed a slight decline with a total of $307,529 against $333,511. Fire brick and stove lining amounted to $413,500 as compared with $464,693 in the preceding year. The output of drain tile was valued at $202,292 against $254,679, and of sewer pipe at $138,258 against $127,731. The production of terra cotta had a value of $718,700 against $1,062,017 in 1910; fireproofing of $229,627 against $256,820; and building tile, inclusive of roofing tile and floor tile, of $82,217 against $65,190. The miscellaneous clay manufactures, including such items as flue lining, fire tile and shapes, conduit pipes and acid-proof brick, amounted in all to $20,179, as compared with $134,752 in 1910. The potteries of the State reported an output valued at $2,196,054 against $2,136,518 in the preceding year.

Among the counties which contributed largely to the year's total Onondaga held first place and reported an output valued at $912,892. In the preceding year it was fourth in the list with a value of $833,892. The potteries at Syracuse were the most important factors in the production. Ulster county ranked second with a reported value of $829,035, represented entirely by common building brick. Erie county maintained its position as the third largest producer and returned a value of $755,602. Rockland county, which was second in 1910, moved to fourth place last year, contributing an output valued at $747,040. The other counties that reported a value in excess of $500,000 were Dutchess ($648,151) and Orange ($565,152).

Production of clay materials by counties

COUNTY	1909	1910	1911
Albany	$750 754	$641 227	$470 503
Allegany	22 601	*a*	9 000
Cattaraugus	*a*	63 887	90 153
Cayuga	15 400	20 675	15 724
Chautauqua	118 897	129 331	166 322
Chemung	61 000	*a*	76 169
Columbia	472 280	454 550	284 475
Dutchess	880 707	649 862	648 151
Erie	753 362	841 726	755 602
Greene	346 982	266 452	139 578
Jefferson	11 175	7 997	*a*
Kings	490 946	569 720	602 756
Livingston	6 900	*a*	70 295
Monroe	278 991	264 421	325 849
Nassau	136 375	111 650	105 740
Niagara	22 923	22 882	25 426
Oneida	83 500	126 907	95 605
Onondaga	834 111	833 892	912 892
Ontario	196 345	269 549	255 298
Orange	814 440	761 500	565 152
Queens	435 182	551 375	402 398
Rensselaer	317 559	348 172	173 564
Richmond	698 991	633 010	470 591
Rockland	1 488 457	1 080 117	747 040
Saratoga	335 670	388 428	393 490
Schenectady	322 549	505 966	486 327
Steuben	205 036	219 615	149 649
Suffolk	68 370	101 560	73 750
Ulster	1 620 468	1 121 460	829 035
Washington	10 950	3 685	10 350
Westchester	438 243	371 328	297 997
Other counties *b*	112 318	158 038	102 778
Total	$12 351 482	$11 518 982	$9 751 659

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a Included under other counties.

b In 1909, aside from counties marked (*a*), are included Fulton, Genesee, Montgomery, New York, St Lawrence, Tioga, Tompkins, Warren and Wayne counties. In 1910, aside from counties marked (*a*) are included Genesee, Montgomery, New York, St Lawrence, Tioga, Tompkins, Warren and Wayne counties. In 1911, aside from counties marked (*a*) are included Clinton, Genesee, Montgomery, New York, St Lawrence, Tompkins, Warren and Wayne counties.

MANUFACTURE OF BUILDING BRICK

The total number of common building brick made in New York State last year was 1,066,982,000. This represented a large falling off from the total reported for 1910 which amounted to 1,396,606,000, the actual decrease being 329,624,000 or 23 per cent. The decline was attributable mainly to the dull conditions in the building trades of the larger cities, notably of New York. The brick yards along the Hudson river which depend almost solely upon the New York City markets for their outlet were operated on a much reduced scale, and their product showed a decrease of nearly 300,000,000 for the year.

The value of the common brick was $5,310,511, or an average of $4.98 a thousand, as compared with $6,563,212, an average of $4.70 a thousand, in 1910. The improved showing was due to the slightly higher prices that were obtained by the manufacturers in the Hudson river valley. In 1909 the average price was $5.31 a thousand. These prices represented the average received at the yards, not inclusive of carriage or selling commissions.

In addition to the common building brick there were manufactured last year 11,037,000 front brick with a value of $132,792. In the preceding year the number of front brick made was 7,739,000 valued at $119,859. The aggregate output of brick for building purposes was thus 1,078,019,000 valued at $5,443,303, against 1,404,345,000 valued at $6,683,071 in 1910. The manufacture of building brick was carried on in 31 counties by a total of 153 companies or individuals. In 1909 there were 32 counties represented in the list with a total of 172 producers. A tendency toward the restriction of the industry to fewer plants and more favorable centralized localities has been in evidence for a number of years. It is more apparent in contrasting the present situation with that for example of 1906 when there were 213 active producers distributed over 37 counties

Production of common building brick

COUNTY	1910		1911	
	NUMBER	VALUE	NUMBER	VALUE
Albany	74 496 000	$390 894	59 517 000	$319 503
Cattaraugus	612 000	5 984	1 088 000	8 109
Cayuga	2 403 000	16 075	1 813 000	11 724
Chautauqua	5 058 000	32 588	4 140 000	28 406
Columbia	92 700 000	454 550	57 695 000	284 475
Dutchess	147 696 000	649 862	133 229 000	648 151
Erie	51 244 000	283 207	35 975 000	222 673
Greene	30 374 000	137 452	28 779 000	139 578
Jefferson	1 068 000	7 997	....	....
Livingston	312 000	2 184	425 000	2 550
Monroe	19 531 000	111 758	21 100 000	116 600
Nassau	17 000 000	107 500	15 790 000	98 445
Niagara	3 434 000	22 882	3 178 000	25 426
Oneida	19 126 000	119 082	14 434 000	93 105
Onondaga	19 569 000	104 534	22 000 000	132 750
Orange	160 500 000	761 500	121 800 000	565 152
Rensselaer	14 600 000	72 800	13 352 000	67 760
Richmond	32 355 000	134 049	23 456 000	106 823
Rockland	251 190 000	1 080 117	162 400 000	747 040
Saratoga	84 639 000	387 268	81 575 000	392 427
Suffolk	16 360 000	98 560	11 500 000	68 750
Ulster	263 873 000	1 121 460	178 287 000	829 035
Westchester	66 836 000	332 027	52 654 000	263 498
Other counties [a]	21 630 000	128 882	22 795 000	138 531
Total	1 396 606 000	$6 563 212	1 066 982 000	$5 310 511

[a] Includes in 1910, Chemung, Clinton, Montgomery, Ontario, St Lawrence, Steuben, Tompkins, Warren and Washington counties. In 1911 the same counties are included excepting Steuben which reported no production.

Hudson river region. The greater part of the brick production of the State is made in the Hudson river valley in the stretch from Albany and Rensselaer counties southward to Rockland and Westchester counties. The existence of extensive clay beds suitable for the common grades of brick, the facilities for cheap transportation, and the proximity to the large market of New York City and vicinity combine to make this section the largest brick-manufacturing district in the United States.

The brick clays are found in terraced deposits on either side of the river, extending from the water level to a height of 300 feet or more in places. They are interbedded with and sometimes covered by layers of sand and gravel. Their thickness at any locality may exceed 100 feet, though usually it is much less. Some clay has been obtained by dredging from the bed of the river, as at Haverstraw. The clays are usually of blue color weathering to red or yellow at the surface, and are quite calcareous with an average of from 3 to 6 per cent lime carbonate. In addition to their employment for common brick, they are utilized to some extent for fireproofing and hollow blocks. Slip clay used for glazing pottery is obtained from certain beds of the Hudson river clays.

The common brick are manufactured by the soft mud process and are burned in scove kilns. Machine molding has been tried successfully on some of the clays, but most manufacturers adhere to the old hand process.

There are more than 125 brick yards in the 9 counties along the river, with a combined capacity under full operation of over one and a quarter billion brick a year. So large an output is seldom warranted, however, by the market requirements, and the average product for recent years has ranged around one billion, reaching a maximum of 1,230,000,000 in 1906.

During the last two seasons the demand for brick has been below normal. At the beginning of 1910 the yards still had a stock of about 200,000,000 on hand that remained unsold and with the year's manufacture the total available supply was about 1,300,000,000, of which only 950,000,000 were actually consumed during that season. Consequently the yards carried over about 350,000,000 to 1911. With this formidable accumulation on hand, manufacturers were naturally loath to begin operations, and the opening of the season was delayed beyond the usual time. Many plants reduced their working force; others remained inactive throughout the year. In spite of this curtailment policy which reduced the outturn below that of any previous season for a long time, the market was not able to absorb the supply. It is estimated that about 250,000,000 brick were on hand at the close of 1911. As the number manufactured was approximately 800,000,000 the consumption may be placed at 900,000,000, or about 50,000,000 less than in 1910.

Despite the unfavorable conditions of demand, prices showed some improvement over those reported for the preceding year. The average price received for common brick throughout the district was $4.78 a thousand against $4.54 a thousand in 1910. This represented the average for the sales at the yard and not the New York prices which ranged about $1.25 a thousand higher, an amount equivalent to the cost of river shipment and commissions exacted by the dealers in New York.

The production for 1911 as given in the table herewith was 807,713,000 and was contributed by 96 plants. It has been many years since so few plants were in operation. The number in 1910 was 114. Ulster county as usual held first place in the industry; its contribution was 178,287,000 valued at $829,035, as compared with 263,873,000 valued at $1,121,460 in 1910. Rockland county was second in the list and Dutchess third, the latter displacing Orange county which ranked third in 1910.

The Greater New York Brick Co. was organized during the year to act as selling agents for the manufacturers.

Output of common brick in the Hudson river region in 1910

COUNTY	NUMBER OF PLANTS	OUTPUT	VALUE	AVERAGE PRICE PER M
Albany	12	74 496 000	$390 894	$5 24
Columbia	6	92 700 000	454 550	4 90
Dutchess	19	147 696 000	649 862	4 40
Greene	5	30 374 000	137 452	4 52
Orange	8	160 500 000	761 500	4 74
Rensselaer	4	14 600 000	72 800	4 98
Rockland	28	251 190 000	1 080 117	4 30
Ulster	24	263 873 000	1 121 460	4 25
Westchester	8	66 836 000	332 027	4 96
Total	114	1 102 265 000	$5 000 662	$4 54

Output of common brick in the Hudson river region in 1911

COUNTY	NUMBER OF PLANTS	OUTPUT	VALUE	AVERAGE PRICE PER M
Albany	10	59 517 000	$319 503	$5 37
Columbia	6	57 695 000	284 475	4 93
Dutchess	15	133 229 000	648 151	4 85
Greene	5	28 779 000	139 578	4 85
Orange	6	121 800 000	565 152	4 64
Rensselaer	4	13 352 000	67 760	5 08
Rockland	24	162 400 000	747 040	4 60
Ulster	20	178 287 000	829 035	4 65
Westchester	6	52 654 000	256 449	4 87
Total	96	807 713 000	$3 857 143	$4 78

OTHER CLAY MATERIALS

The manufacture of vitrified paving brick was carried on by four companies in Cattaraugus, Chautauqua, Erie and Steuben counties, the same number as in 1910. The number of paving brick made was 18,996,000 valued at $307,529 against 19,762,000 valued at $333,511 in the preceding year. The price received for paving brick averaged $16.19 a thousand, as compared with $16.88 a thousand for 1910.

The production of fire brick and stove lining was made in Erie, Kings, Rensselaer, Richmond, Schenectady, Washington and Westchester counties, and was valued at $413,500 against $464,693 in the preceding year. Fire brick numbered 7,192,000 valued at $330,659. The stove lining was valued at $82,841. There were 9 companies in operation, or 2 less than in 1910. Most of the refractory clay used by the manufacturers was obtained from without the State, though the company in Richmond county obtained its supply locally.

The output of drain tile was distributed among 9 counties, with Albany as the largest producer. The value of the output, $202,292, showed a considerable decline from the total of $254,679 reported in 1910. There were 16 firms engaged in the industry, 2 less than in the preceding year. The production of sewer pipe, mainly from Monroe county, reached a value of $138,258 against $127,731 in the preceding year. It was contributed by 3 companies.

Fireproofing, including terra cotta lumber, hollow brick, and various other kinds of hollow fireproofing, was made last year by 7 firms, distributed among Erie, Kings, Monroe, New York, Oneida, Onondaga and Rensselaer counties. The value of the output was $229,627 as compared with $256,820 in 1910, when 8 firms were active. Local clays are used for its manufacture. The use of fireproofing has grown quite rapidly and there would seem to be opportunity for an enlarged development of the local industry.

Building tile, inclusive of roofing tile, vitrified floor tile and terra cotta tile, was reported from Allegany, Erie, Kings and Monroe counties by a total of 4 firms, 2 less than in 1910. The output was valued at $82,217 against $65,190 in the preceding year. This is another department of the clay-working industry which deserves greater attention than it has received in the past.

Architectural or ornamental terra cotta declined in value from $1,062,017 in 1910 to $718,700 last year. Its manufacture is carried on by 3 firms in Queens, Richmond and Steuben counties. The Staten Island cretaceous clays are used in part for this product.

The miscellaneous clay materials accounted for a value of $20,179 against $134,752 in 1910.

POTTERY

New York is deficient in clays suitable for the finer grades of pottery such as china and porcelain ware. The clay beds of Long Island, Staten Island and Onondaga county have supplied some stoneware clays, and slip clay of excellent quality is obtainable at Albany. Common earthenware clays also are abundant. There are no kaolin deposits supplying pottery material, and the entire requirements of the local manufacturers are met by purchases from southern mines or by importations from abroad.

Notwithstanding the limitations of resources, the pottery industry has shown a fairly steady growth. The output last year was valued at $2,196,054 and was the largest that has ever been recorded. The corresponding total for 1910 was $2,136,578 and for 1909 it was $1,827,193. The potteries contributing to the total numbered 21, 1 less than in the preceding year, distributed among the following counties: Albany, Erie, Kings, Livingston, Nassau, Onondaga, Ontario, Queens, Schenectady, Suffolk and Washington. Onondaga county alone reported a production valued at $774,477.

Of the various pottery products stoneware is one of the few that has not shared in the general advance of the industry. The production in 1911 was valued at $39,095, or less than one-half of the output five years ago. Red earthenware consisting mainly of flower pots, amounted in value to $32,495, about the usual average. The white products, including china tableware, sanitary ware and electrical supplies, have shown the largest gains; the porcelain and semiporcelain wares were valued at $1,026,517. Most of the china tableware was made in Syracuse and Buffalo, the electrical supplies were made in Victor, Syracuse, Schenectady and Brooklyn; and the sanitary wares in Brooklyn.

Value of production of pottery

WARE	1909	1910	1911
Stoneware	$41 298	$41 925	$39 095
Red earthenware	32 800	25 713	32 495
Porcelain and semiporcelain [1]	999 663	1 027 249	1 048 872
Electric and sanitary supplies	697 573	991 131	1 026 517
Miscellaneous	55 859	50 500	48 075
Total	$1 827 193	$2 136 518	$2 196 054

[1] Includes china tableware and cream-colored ware.

CRUDE CLAY

The clay obtained in a few localities is not utilized by the original producer but is shipped to others for manufacture, some of it going to points outside the State. This production, therefore, is listed separately from that of clay materials. The clay most extensively exploited for shipment is the Albany slip clay which is found in layers within the ordinary brick clay of the Hudson valley. It resembles the latter in appearance but has a finer grain and a larger percentage of the alkaline constituents than the usual run of the deposits. It has consequently a low fusibility and when applied to clay wares as a " slip " gives a rich brown glaze.

The light-colored refractory clays of Long Island and Staten Island and various pottery clays are also shipped to some extent. Returns were received from 6 producers in 1911 and their total shipments of crude clay amounted to 14,193 short tons valued at $11,982. In the preceding year the reported shipments amounted to 6005 short tons valued at $9667. The relatively higher value assigned to the product in 1910 is explained by the large proportion of slip clay included in the total.

EMERY

The mining of emery has been carried on for a number of years near Peekskill, Westchester county, one of the few places in this country where the material is known to occur in quantity. The industry is small, as the native emery does not find so wide a market as the Grecian and Turkish product which can be imported at low cost.

The Peekskill emery is a mixture of corundum, spinel and magnetite chiefly, though the mineral composition is rather variable.

The corundum, which is the most valuable constituent from the abrasive standpoint, may constitute as much as 50 per cent of the entire rock, and in the typical material is often seen in the form of large porphyritic crystals scattered through a fine-grained mass of magnetite and spinel. The rock is dense and hard, of dark gray to nearly black color, sometimes mottled by the lighter crystals of corundum. It occurs as lenticular and banded masses within local intrusions of basic gabbroic rocks which are known as the Cortlandt series. The emery masses are believed to represent segregations of the heavier minerals of the gabbro while the latter were in a molten condition, a process similar to that which led to the formation of the titaniferous magnetites in the anorthosites and gabbros of the Adirondacks. Some of the deposits in Westchester county contain a fairly high percentage of magnetite and were once mined for iron ore, but owing to the high alumina content proved too refractory for furnace use.

The output of emery last year was below the usual average, showing a decline of about 200 tons from the total reported in 1910. The actual amount reported by the producers was 769 short tons with a value of $8810. In 1910 it was 978 short tons valued at $11,736. The maximum product for any recent year has been about 1500 tons.

The emery is all shipped in lump form to abrasive manufacturers, who grind and prepare it for use. The list of producers in 1911 included the Blue Corundum Mining Co., Easton, Pa.; Keystone Emery Mills, Frankford, Pa.; and John Buckbee, Peekskill. In former years the Hampden Corundum Wheel Co. and R. Lancaster have been active in the district.

FELDSPAR

The commercial grades of feldspar are obtained in this State from pegmatite bodies that accompany the crystalline formations of the Adirondacks and the southeastern Highlands. The pegmatite has the composition of granite and represents a coarse phase of that rock originating through specially favorable conditions of crystallization supplied, perhaps, by abundance of water vapor. It is commonly associated with granites and granitic gneisses, but may be found as offshoots or independent bodies surrounded by rocks of quite different character. In the granite areas it occurs frequently in lenticular and irregular masses which show no distinct boundaries but grade by imperceptible stages into the finer-grained rock. Elsewhere the pegmatite shows intrusive relations with the county rocks, forming dikes and bosses with well-defined walls.

The feldspar is predominantly a potash variety, that is either orthoclase or microcline, but soda feldspar or albite and the lime-soda varieties are frequently represented. Microcline is by far the commoner of the potash feldspars in the New York localities. For pottery purposes it is an advantage to have the feldspar in large well-segregated crystals or masses so that it can be readily freed from the accompanying minerals. In the pegmatites which are quarried for pottery spar, the crystals range up to 3 or 4 feet in diameter. The pegmatites of finer texture and those in which the minerals are intimately intergrown have application principally for roofing material.

Quartz is an important ingredient of all pegmatites and if obtainable in pure condition may also have value. It is an important by-product, for example, of the Bedford quarries. It occurs in irregular masses, seldom showing any traces of crystal form, and is of gray, white, or pink color. When intergrown with the feldspar to any extent it detracts from the value of the latter for pottery use, though quartz is a necessary ingredient of the pottery mixture.

The accessory constituents of the pegmatites include a variety of minerals of which the commoner are the micas, hornblende, pyroxene, and tourmalin, while of less frequent occurrence are garnet, magnetite, pyrite, epidote, titanite, and beryl. Black tourmalin is nearly always present in the Adirondack pegmatites. These constituents may be of determinative importance with reference to the commercial value of a pegmatite occurrence, since if disseminated through the mass they preclude the extraction of high-grade material.

The only feldspar quarries that have been worked during the past year are situated in Westchester and Essex counties. Those near Bedford, Westchester county, have yielded most of the higher grade product used for pottery and enamel ware; they are operated by P. H. Kinkel's Sons. They are opened in a large mass of pegmatite that outcrops on the eastern and northern slopes of the hill lying a little south of Bedford village. In addition to the feldspar there is a considerable output of quartz which is sold for wood filler. The feldspar is shipped in three grades, of which no. 1

grade consists of pink microcline practically free of quartz. It is all sold in crude condition for pottery use. No. 2 consists of white albite with more or less quartz and is ground at the local mill before shipment. It goes mainly to enamel ware manufacturers. No. 3 grade carries quartz, as well as more or less of the iron-bearing minerals, and finds application in glass manufacture. It is likewise ground locally.

The quarries in Essex county are situated near Ticonderoga and Crown Point. Those at the former locality are owned by the Barrett Manufacturing Co., which utilizes the product mostly for prepared roofing material. The pegmatite is broken down and sent to the mill without sorting. It is thus a mixture of feldspar, quartz and other minerals.

The quarries of the Crown Point Spar Co., just south of Crown Point, produce crushed feldspar for roofing purposes, poultry grit and concrete, and some that finds use in enamel ware. They are situated on top of Breed's hill, an elevation mainly composed of black hornblende-biotite gneiss in which the pegmatite appears to form a bosslike intrusion measuring several hundred feet in diameter. The feldspar consists of pink microcline and white or greenish albite. It is frequently intergrown with quartz, but may form separate masses up to 5 or 6 inches in diameter. Biotite is the chief dark mineral and appears in seams, or as a coating on the feldspar. The pegmatite has been squeezed or fractured, and there is a noticeable development of secondary chlorite. The quarries are connected with the mill which is situated at the lakeside over a mile away by an aerial tram. The product is there crushed and graded into different sizes for use as roofing material, poultry grit, and in concrete. A part of the product is sold also to the enamel ware trade.

The production of feldspar, including crushed unsorted pegmatite, amounted in 1911 to 15,652 short tons valued at $61,769. This showed a slight gain compared with the totals reported for previous years. In 1910 the output was 12,132 short tons valued at $46,863 and in 1909 it amounted to 13,871 short tons valued at $46,444. Market prices remained unchanged; the crude feldspar for pottery uses brought about $3 a ton, the ground spar for pottery and enamel ware $6, and the crushed material for roofing, poultry grit, etc., about $3 a ton.

NOTES ON THE OCCURRENCE OF FELDSPAR IN NEW YORK

It is the purpose of the present notes to call attention to some little known or undeveloped feldspar deposits which were visited in the summer of 1911 during the course of a field investigation of the granite quarries of the State. A report on the feldspar deposits of the United States was issued in 1910 by the United States Geological Survey. The report, contributed by Edson S. Bastin, contains a very detailed description of the better known local occurrences from which the supplies of feldspar have been obtained in recent years, but omits mention of those here considered.

Crown Point, Essex county. The pegmatite occurrence called Roe's spar bed has been a source of feldspar for pottery purposes, having been worked some 15 years ago and the product shipped to potteries outside the State. It has received only fugitive attention in the geological reports relating to Essex county, though mentioned in one of the papers by J. F. Kemp as an important deposit. It is chiefly known at present as an interesting mineral locality.

The deposit is most conveniently reached from Crown Point, from which it lies about 8 miles distant in a northwesterly direction. It outcrops about 1 mile directly south of Towner pond at an elevation of between 1100 and 1200 feet, as shown on the topographic map. It is now the property of Mr H. W. Willcox.

The old quarry working shows a face about 50 feet high and 75 feet wide in a body of pegmatite which seems rather a lenticular or boss-shaped mass than a dike. The outlines, however, are not clearly revealed by outcrops and there is some uncertainty as to the extent of the deposit. The longer axis appears to run about n. 50° e., as indicated by a series of openings below the main quarry which follows that direction. The width of the exposed part at right angles is from 75 to 100 feet.

The pegmatite is very coarse and the components well segregated. Feldspars with a diameter of 3 feet are not uncommon. They often show crystal boundaries. Quartz is of subordinate importance, but is rather unequally distributed. It is partly of pink color and partly the milky variety. Graphic intergrowth of quartz and feldspar is not abundant. The iron-bearing minerals are chiefly biotite and tourmalin and though fairly plentiful on the whole they are usually concentrated in certain parts of the deposit so that their presence would not necessarily entail any great waste in the production of pottery material. The existence of trap dikes, of which four were noticed in the quarry face, varying from 1 inch to 4 feet thick, is of some consequence though probably not a very serious drawback.

The feldspar includes a pinkish variety which shows the characteristic optical properties of microcline and a light-gray oligoclase. They appear to be in about equal amounts.

In the former operations which were carried on by Mr Roe, the spar was hauled to Crown Point for shipment. The costs of haulage are reported to have been $1.50 a ton in summer and $1.25 in winter. The stretch of road from the quarry to Crown Point Center is over a rough country but chiefly with descending grade.

Chestertown, Warren county. There are openings in a pegmatite body that is situated on the north side of a high ridge about 3 miles south of Chestertown and 1.5 miles east of the Warrensburg road. They are said to date back about 15 years. The purpose of the operations was to produce mica rather than feldspar. Two workings may be seen of which the principal one lies to the south and higher up on the ridge. This consists of an open cut about 50 feet long and 15 feet wide on a dike or elongated body of pegmatite that strikes northeast. The limits of the mass are indeterminate except on the east side of the pit where the county rock is exposed a few feet away. The northern pit reveals very little as to the size of the pegmatite mass or the conditions of its occurrence, being a narrow opening which at the time of the writer's visit was filled with water. It may be on a separate body.

The pegmatite is a coarse intergrowth of white feldspar, quartz and mica. The last named mineral is chiefly biotite with a brownish variety in subordinate amount. The latter may be muscovite but it is not of good quality being in imperfect crystals that show rulings. The largest crystals measure about a foot in diameter. Black tourmalin is quite common in the feldspar and quartz. The feldspar appears in pure masses and also as graphic intergrowths with the quartz. It belongs to the potash variety with the optical properties of microcline.

Fort Ann, Washington county. An exposure of pegmatite near this place has been worked at different times for feldspar and quartz. It is reported as one of the localities from which quartz was obtained for grinding at the mill that was operated at Fort

Ann about 25 or 30 years ago. More recently it has been a source of feldspar for shipment and has been worked intermittently according to the market demand, the last time by Dominick Ashley of Glens Falls.

The outcrop lies about 2½ miles northwest from Fort Ann at the base of the gneiss ridge of which the higher part is known as Putnam mountain. It is on or near the farm of Ira D. Gilmore. It consists of a rather irregular area, though the general shape is lenticular, with its longer direction nearly transverse to the general axis of the ridge, or to the northwest. An open cut about 125 feet long and from 30 to 40 feet deep has been made. The lens is broadest near the southeastern end where it measures fully 75 feet wide. To the northwest it gradually diminishes and wedges out in the gneiss 50 feet beyond the end of the pit. When visited by the writer the workings were partly filled with water and the deeper parts of the excavation consequently could not be inspected. The wall rock as seen in exposures nearby is a well-laminated biotite gneiss.

The pegmatite is made up largely of graphic granite, that is an intimate mixture of feldspar and quartz, but the two minerals also occur separately to a considerable extent. Masses of milky quartz up to 2 or 3 feet in diameter are found and also feldspar crystals of similar dimensions. The feldspar is mainly of grayish color and so far as tested appears to consist largely of microcline. There is present also a little pinkish feldspar which may be orthoclase. Tourmalin and the iron-bearing silicates generally have a very limited representation, though the pegmatite shows much iron stain, the result perhaps of pyrite.

Alteration of the feldspar is much in evidence in parts of the exposure. This results in the formation of kaolin and sericite and sometimes is accompanied by a greenish coloration of the secondary products which is probably the effect of intermingled serpentine. The presence of this mineral can not be traced to any magnesium component of the pegmatite, but seems referable to an interchange of the alkaline constituents of the feldspar for magnesium which has been introduced perhaps by ground waters.

Kushaqua, Franklin county. A large pegmatite body is found about 4 miles north of this place on the slopes of Sable mountain. It has been prospected during the last few years but has not supplied any feldspar in commercial quantity. The outcrop lies high up on the mountain near the summit at an elevation probably of about 2500 feet above sea level. It is reached by a rough trail from Kushaqua.

Two openings have been made in the body which is elsewhere concealed by surface materials. The lower of these exposes the pegmatite over a width of 50 feet and a depth of 25 feet. The upper opening is a little smaller. There are said to be other prospects on the mountain which were not visited but which indicate that the pegmatite has the form of a dike and continues for over half a mile along the strike.

The feldspar is red microcline, showing little tendency to assume regular outlines. The rough and somewhat broken masses measure a little over a foot in diameter as a maximum. It is rarely free from admixture with other minerals and consequently could not be quarried to advantage for pottery use. Hornblende, tourmalin and biotite are the chief iron-bearing silicates.

De Kalb, St Lawrence county. The existence of a ledge of coarse pegmatite in this section was made known to the writer by J. H. McLear of Gouverneur. The locality is between East De Kalb and Bigelow, about 3 miles north of the latter place. The pegmatite is exposed in a natural outcrop that has not as yet been developed.

The principal showing consists of a ledge which exposes the pegmatite for a distance of 75 feet along the strike and 40 feet across it and then disappears below the surface deposits. The outcrop is fresh and free from iron stain. The pegmatite consists of white feldspar and milky quartz in fairly pure aggregates in a matrix formed by a fine intergrowth of the same minerals. The individual feldspar crystals range from 6 inches to 3 feet in maximum diameter. There appears to be very little admixture with other minerals usual to pegmatites. Pyrite, however, may be observed occasionally in the quartz. A second ledge in the same line of outcrop is exposed about 300 feet distant from the first, with similar characters. The quality of the feldspar so far as it may be estimated under the conditions, appears to be fairly good. The samples that were examined show it to be practically all microcline. A quantity of first-grade material could be extracted, but the main part owing to admixture with quartz would have to pass probably as lower grade. There is need for thorough prospecting to confirm the estimate that is formed on the surface showing, as well as to determine the size of the body.

Fowler, St Lawrence county. A dike of pegmatite carrying finely crystallized feldspar is found on the farm of C. W. Denesia about 2 miles south of Fullerville in the town of Fowler. It is only exposed, however, over a very limited area and where seen its width is not over 8 feet. The feldspars are developed in prismatic crystals from 2 to 3 feet long. They are inclosed in a ground mass of intergrown quartz and feldspar with which tourmalin and biotite are associated. They consist of a deep red microcline and a pinkish variety which is an intergrowth of microcline and albite. Unless the dike proves of greater magnitude than is indicated by the exposed part it would hardly be workable.

Fine, St Lawrence county. The occurrence of pegmatite on the farm of Fred Scott, about 4 miles north of Oswegatchie in the town of Fine, is of interest particularly for the associated minerals. These include fluorite, hornblende, pyroxene, pyrite, chalcopyrite and titanite in well-crystallized individuals. The feldspar occurs in pink, white and greenish varieties, evidently representing both the potash and lime-soda series. It is too much intergrown with the other minerals to have commercial value.

GARNET

The Adirondack garnet mines reported an output last year of 4285 short tons with a valuation of $121,759. This was less than in 1910 when the total amounted to 5297 short tons valued at $151,700 but may be considered as about the average outturn. The production has varied from year to year according to the activity of the market but at no time has taxed the full capacity of the mines. In fact the demand for abrasive garnet has shown very little tendency to increase, and there would seem to be little opportunity at present for the development of new sources of supply.

No important changes in the industry have taken place during the past year. The principal producers, as heretofore, were the mines in the vicinity of North River. The largest factor in the industry has been for some time the North River Garnet Co. with mines and milling plant on Thirteenth lake, Warren county. The other active mines in that section included those on Gore mountain owned by H. H. Barton & Son Co. and those of the American Glue Co., a little farther north in Essex county. At Riparius, the Warren County Garnet Mills have operated in a small way. In northern Essex county near Keeseville the American mine shipped some material.

The conditions surrounding the occurrence of garnet in the Adirondacks have been described in several papers and in previous issues of this report. The mineral is fairly widespread as a constituent of the metamorphosed igneous and sedimentary rocks, but only in a few places is it found in sufficient abundance and with the requisite characters to be worked for commercial abrasive purposes.

The value of abrasive garnet depends, of course, primarily upon its hardness. This is a variable character and on the usual mineral scale garnet is classed as having a hardness of from 6.5 to 7.5. The limits as given are only approximate, as it is difficult and even impossible to estimate hardness with precision. Chemical composition is undoubtedly a factor in determining the hardness of the common kinds of garnet found in the metamorphosed rocks, like gneisses, schists and crystalline limestones. The iron-alumina variety (almandite) is generally harder than the lime-alumina (grossularite), or the lime-iron variety (andradite). Well-crystallized garnet is tougher and probably also harder than the granular or massive garnet of similar chemical composition. The property of toughness or tenacity is very important in an abrasive which has to withstand considerable pressure as when used as polishing machines. Another factor which has a bearing upon the value of abrasive garnet is the size of the product which can be secured in the ordinary practice of mining and separation. If the crystals are small or have been badly shattered by compression after crystallization the product may be too fine to yield the necessary assortment of commercial sizes. It is an advantage, however, that the garnet should possess an imperfect cleavage or parting, so that on crushing the grains show one or more smooth surfaces. These surfaces permit firm attachment to the cloth or paper and also provide a sharp cutting edge. Color is no criterion of quality in ordinary garnet, but abrasive users seem to prefer the darker shades of red which approach the distinctive garnet color.

The local industry has very little competition from other mines in this country. Mines have been worked at different times in New Hampshire, Massachusetts, Pennsylvania and North Carolina but have not proved permanent factors in the trade. The importation of Spanish garnet, first noted in 1907, has assumed some importance as a substitute for the finer sizes of the Adirondack mineral. This garnet is said to be obtained by concentration of alluvial sands and can be produced cheaper than the domestic garnet, but comes only in the finer sizes. It pays no import duty. The importations in 1911 were 693 short tons, with an invoice value of $10,526. In 1900 they amounted to 775 short tons valued at $14,830. The principal ports of entry are New York, Boston and Chicago, and the shipments are made from both Spanish and British ports.

GRAPHITE

No noteworthy developments were recorded for the graphite industry during 1911. The production amounted to 2,510,000 pounds, about the usual quantity, and represented a value of $137,750. The total for the preceding year was 2,619,000 pounds, with a value of $160,700. Prices appeared to be somewhat lower; the reported average was about 5.5 cents a pound, as compared with 6.1 cents in 1910.

The American mine at Graphite, owned by the Joseph Dixon Crucible Co., continued as the leading producer. This mine has long been the largest and most successful of the kind, not only in the State but in the country as well, and may be considered the pioneer enterprise in all that relates to the technology of treating the disseminated flake graphite which constitutes the principal source of domestic production. The methods of extracting and refining the graphite as developed by its management have seldom been applied elsewhere with similar results, owing in some measure undoubtedly to the unusually favorable natural conditions found at Graphite. The ore is a quartzite carrying flakes of graphite distributed along the cleavage planes. The flakes are relatively of large size, showing the appearance of having been squeezed out by regional compression, and measure up to one quarter inch in diameter. The average content in graphite may be placed at about 6 or 7 per cent. What is most important to the success of the milling operations is the practical absence of micaceous minerals which are more or less common in the graphitic schists and quartzites of the Adirondacks. When present in any amount a high-grade graphite product can not be expected.

The deposits of the American mine have a northeast-southwest strike and their extension to the southwest is found on the adjoining lands owned by W. H. Faxon of Chestertown, N. Y. This property has been explored recently with considerable thoroughness by test pits and diamond drilling, but still awaits active development. The exploration has demonstrated the continuity of the graphite beds over a distance of fully 4000 feet along their course to the southwest and with some interruptions for several hundred feet on the dip which follows a low angle to the southeast. The same series of gneisses, limestones and graphitic quartzites is found here as in the area under exploration. The graphitic quartzite that constitutes the principal ore body has a thickness ranging from 5 or 6 to 25 feet, showing local pinches and bulges as is usual in the Adirondack deposits. There is considerable variation in the size and abundance of the flake, but as a whole the character of the quartzite is quite like that in the American mine. Near the southwestern end of the property the graphite series outcrops in a little ravine where a short drift has been extended into the north bank; two distinct beds are found here separated by a band of garnetiferous gneiss. In a drill hole (No. 2) 300 feet or so northeast of the drift a similar relation holds, the upper bed measuring about 4 feet and the lower 18 feet thick with 26 feet of gneiss between them. The two beds appear to merge a little further northeast for in No. 3 drill hole just east of the camp a single seam over 20 feet thick was encountered and this apparently continues with local variations as to thickness to the northeastern limits of the property, except in one place where the series is invaded by a gabbro intrusion. The deepest hole, No. 7, was put down in the flat about 600 feet east of No. 3 and twice that distance from the outcrop of the graphite bed on the ridge to the northwest. The data for this boring have been kindly supplied by Mr Faxon and are illustrative of the general conditions under which the graphite occurs.

	THICKNESS	
STRATA	FEET	INCHES
Rock with large flake graphite	2	0
Garnetiferous gneiss	20	0
Garnetiferous gneiss and limestone	24	0
Limestone	9	0
Limestone and quartz	8	10
Limestone	36	8
Black rock (hornblende?)	4	0
Limestone	5	3
Lost core	1	6
Graphite	0	6
Good flake graphite	5	4
Fine flake graphite	5	6
Good large flake graphite	12	2
Garnetiferous gneiss	24	0
Black rock	5	8
Total	164	5

In hole No. 1 on the northeast, next to the American property the graphite bed measured 20 feet thick.

The Empire Graphite Co., owning mines in the town of Greenfield, Saratoga county, 4 miles west of Kings, was active during a part of the year. The work consisted mainly of development incident to a change from surface to underground methods of mining. The deposit along the outcrop has been decomposed with the formation of clayey matter which complicated the separation of the graphite. The matrix is a feldspathic quartzite resembling that at the American mine, but the flake averages a little smaller in size. Two distinct beds are in evidence, separated by 4 feet of limestone and barren quartzite. The upper bed has a thickness of from 10 to 14 feet and the lower of from 4 to 5 feet. The immediate walls consist of mica schist, carrying pyrite, but thick-bedded garnetiferous gneisses occur in the upper part of the series, south of the workings. The outcrop of the beds strike nearly east and west and is marked by a slight depression in the easterly sloping ridge. It is traceable for 1500 feet or more from the present mine openings which are at the eastern end of the outcrop. The dip is about 30° south. The principal development aside from the open cuts consists of an adit driven in the side hill along the course of the upper seam for a distance of about 125 feet. Additional workings will be necessary before the mill can be maintained in steady operation. This is a large concrete structure situated on the side hill at the mines. It is equipped with a gyratory crusher, 10 stamps, and rolls for the reduction of the ore. The separating equipment includes buddles, settling tanks, screens and dryers.

The Saratoga Graphite Co. has lately erected a mill near Kings Station north of Saratoga Springs.

The other properties in the eastern Adirondacks that have been active during the last few years include the Conklingville mine of the Sacandaga Graphite Co., and the mine near Chilson lake, owned by the Crown Point Graphite Co.

A small quantity of graphite has been shipped recently by the Macomb Graphite Co., from its property near Popes Mills, St Lawrence county.

GYPSUM

The remarkably rapid progress that has characterized the gypsum industry during recent years was interrupted in 1911 and the output showed a decline amounting to about 4 per cent. The setback may be attributed doubtless to the lessened activity in the building trades, as most of the output was used for the manufacture of calcined plasters and for admixture with portland cement. There was a similar falling off in many other industries based on the production of building and structural materials. It may also be said that the period of rapid expansion marking the development stage of the gypsum industry is probably over and that progress henceforth will be slower and less constant than in the past.

The output based on the crude rock mined or quarried last year amounted to 446,794 short tons. The corresponding total for the preceding year was 465,591 short tons, showing a decrease of 18,797 short tons, compared with a gain of 87,359 tons in 1910. With the one exception the product last year was the largest on record.

Of the total as given about 70 per cent was consumed by the local calcining plants operated in connection with the mines for the manufacture of plaster of paris and wall plasters. The reports of these plants showed a production of 262,249 tons of calcined plasters with a value of $871,106. The outturn for 1910 was 250,228 tons valued at $838,340. The quantity of gypsum ground for land plaster was reported as 9959 tons valued at $18,508, against 12,597 tons valued at $28,100 in 1910. The sales of crude or lump gypsum, chiefly to portland cement works, accounted for 144,035 tons valued at $202,984, as compared with sales of 178,518 tons valued at $256,512 in the preceding year.

Production of gypsum

MATERIAL	1910		1911	
	SHORT TONS	VALUE	SHORT TONS	VALUE
Total output, crude..........	465 591	....	446 794	....
Sold crude..................	178 518	$256 512	144 035	$202 984
Ground for land plaster......	12 597	28 100	9 959	18 508
Wall plaster, etc. made.......	250 228	838 340	262 249	871 106
Total..................	....	$1 122 952	....	$1 092 598

The output of gypsum and gypsum products as given was reported by 14 firms and was divided among the five counties of Onondaga, Cayuga, Monroe, Genesee and Erie. The greater quantity of rock was obtained in the western section where it found use mainly in the production of calcined plasters.

In Onondaga county there was less activity than usual. The Fayetteville Gypsum Co. produced most of the crude gypsum obtained in the county and shipped the output to New York City for calcination. The property operated by the company was the

Severance quarry near Lyndon, notable for the great thickness of the gypsum beds which are exposed around the summit of a hill and have a vertical extent of from 40 to 60 feet. They are worked by open cut excavation, after first blasting down the overlying shale and limestone which are from 20 to 25 feet thick. The lump gypsum is loaded on 20-ton wagons and hauled 2 miles by a traction engine to the Erie canal for shipment. The quarry formerly worked by the National Wall Plaster Co., in the same vicinity, produced some gypsum which was ground in the local mills to land plaster.

The quarries at Union Springs, Cayuga county, were worked during the year by local interests, the lease under which they had been operated for several years by the United States Gypsum Co. having expired. Most of the output from this place has been used for land plaster and for portland cement. The gypsum ranges from 20 to 30 feet thick and is worked by quarry methods.

In Monroe county around Garbutt the usual activity was manifest, though there was one less producer than in the preceding year. The Garbutt Gypsum Co., one of the pioneers in the district, closed down its mine and mill. The active companies were the Consolidated Wheatland Plaster Co., the Empire Gypsum Co., the Lycoming Calcining Co., and the Oatka Gypsum Co., the last named succeeding the Monarch Plaster Co. The gypsum occurs in two seams, each from 5 to 8 feet thick, separated by from 6 to 12 feet of limestone. Only the upper seam has thus far been attacked. The work is all underground, conducted through adits or shallow vertical shafts. About one-fourth of the output last year was marketed as crude or ground raw gypsum, the rest being converted into calcined plasters. Monroe county held second place in quantity and value of its products.

The active mines in the western section were those of the United States Gypsum Co. and the Niagara Gypsum Co. near Oakfield, Genesee county, and of the American Gypsum Co. and the Akron Gypsum Co. near Akron, on the Erie-Genesee county boundary. Their output was consumed mainly in the manufacture of wall plasters by the plants located at the mines. The American Gypsum Co., however, shipped most of its output to portland cement makers. The gypsum beds in this section are rather thin, averaging not more than 4 or 5 feet, but they are of high-grade character, well adapted for calcination. The mines are worked through vertical shafts in a manner similar to that employed in coal mining. Their equipment and management are based on the most modern approved methods, some of the mines being operated by electric power.

IRON ORE

The record of the iron mining industry last year was uneventful. The reports from the individual companies covering the year's operations indicated the usual number of active enterprises but the average quota was less than for some time and in most sections diminished attention was given to exploration and development work. Unsatisfactory market conditions were responsible for the poor showing. The large production of iron in the preceding year proved to be in excess of the market requirements and brought on a slump which extended well into the season of 1911. There was consequently very little inquiry for ore during the early months. The absorption of the surplus output was facilitated by radical price cutting and by the middle of the year the conditions so far as related to the demand were somewhat improved. This change in the situation proved permanent and enabled the mining companies to dispose of most of their output for the year though at reduced prices. At the close of the season the outlook for the immediate future seemed fairly encouraging.

The production of iron ore in the State during the last two decades is shown in the accompanying table. The figures are based on lump ore and concentrates of commercial grades and not on the mine output which is considerably larger. The volumes of the *Mineral Resources* published by the United States Geological Survey have supplied the data for the years previous to 1904.

Production of iron ore in New York State

YEAR	MAGNETITE	HEMATITE	LIMONITE	CARBONATE	TOTAL	Total value	Value per ton
	Long tons	Long tons	Long tons	Long tons	Long tons		
1891	782 729	153 723	53 152	27 612	1 017 216	....	.....
1892	648 564	124 800	53 694	64 041	891 099	$2 379 267	$2 67
1893	440 693	15 890	35 592	41 947	534 122	1 222 934	2 29
1894	....	....	....	....	242 759	....	.....
1895	260 139	6 769	26 462	13 886	307 256	598 313	1 95
1896	346 015	10 789	12 288	16 385	385 477	780 932	2 03
1897	296 722	7 664	20 059	11 280	335 725	642 838	1 91
1898	155 551	6 400	14 000	4 000	179 951	350 999	1 95
1899	344 159	45 503	31 975	22 153	443 790	1 241 985	2 80
1900	345 714	41 467	44 891	6 413	441 485	1 103 817	2 50
1901	329 467	66 380	23 362	1 000	420 218	1 006 231	2 39
1902	451 570	91 075	12 676	Nil	555 321	1 362 987	2 45
1903	451 481	83 820	5 159	Nil	540 460	1 209 899	2 24
1904	559 575	54 128	5 000	Nil	619 103	1 328 894	2 15
1905	739 736	79 313	8 000	Nil	827 049	2 576 123	3 11
1906	717 365	187 002	1 000	Nil	905 367	3 393 609	3 75
1907	853 579	164 434	Nil	Nil	1 018 013	3 750 493	3 68
1908	663 648	33 825	Nil	Nil	697 473	2 098 247	3 01
1909	934 274	56 734	Nil	Nil	991 008	3 179 358	3 21
1910	1 075 026	79 206	4 835	Nil	1 159 067	3 906 478	3 37
1911	909 359	38 005	5 000	Nil	952 364	3 184 057	3 34

The production in 1911 as reported by all the active mines was 952,364 long tons valued at $3,184,057. Compared with the reported output of 1,159,067 long tons for 1910 there was a decline of 206,703 tons or about 18 per cent. The average value was $3.34 a ton against $3.37 a ton in the preceding year; but the decline in the market prices was greater than indicated by this comparison since the average grade of the ore as shipped was considerably higher in 1911 than in 1910.

Of the output magnetite constituted a total of 909,359 long tons and represented a value of $3,088,869. The quantity of hematite mined was 38,005 long tons, all from the Clinton belt, with a value of $88,188. A few thousand tons of limonite were shipped from the Dutchess county district. No carbonate ore was produced.

The output of magnetite was made up largely of concentrates and consequently did not represent the full quantity of that ore hoisted from the mines. The actual mine output of magnetite was 1,215,868 tons. The total quantity of ore of all kinds hoisted during the year therefore was 1,258,873 tons. In 1910 the corresponding total was 1,517,880 tons.

The list of companies that were active in the industry last year included for the Adirondack region: Witherbee, Sherman & Co. and the Port Henry Iron Ore Co., at Mineville; the Cheever Iron Ore Co., Port Henry; the Chateaugay Ore and Iron Co., Lyon Mountain; and the Salisbury Steel and Iron Co., Salisbury Center. The Benson Mining Co., at Benson Mines, was engaged in erecting a new mill but did not contribute any output last year. The producers of magnetite in southeastern New York were the Hudson Iron Co., Fort Montgomery, and the Sterling Iron and Railway Co., Lakeville. The single producer of limonite in the region east of the Hudson river was the Amenia mine. The output of hematite was made by C. A. Borst, Clinton; Furnaceville Iron Co., Ontario Center; and Ontario Iron Ore Co., Ontario Center.

Mineville. The two companies at Mineville maintained steady operations throughout the year, though on a somewhat reduced scale as compared with their output in 1910. The amount of ore hoisted was reported as 734,353 tons, against 953,553 tons in the preceding year, which was the largest on record.

The mines operated by Witherbee, Sherman & Co. included the Old Bed, Harmony and Barton Hill groups. Both lump ore and concentrates were shipped, the concentrates being supplied from No. 1 and No. 2 mills on the Old Bed and No. 3 mill on the Harmony group. The lump ore came from the Old Bed.

The Old Bed workings, reached through the Joker and Bonanza shafts, have been enlarged recently by the development of a separate bed underlying the main deposit. This lower ore body spreads over a considerable area as a nearly flat sheet, in strong contrast with the complex overlying body, and has a thickness up to 30 feet. The ore resembles that of the Old Bed proper, but contains a little less apatite. Both the Joker and Bonanza shafts have been connected through to the deposit which furnished last year about one-half of the quantity hoisted from the Old Bed group. The ore body extends for a considerable distance to the north and west, and it is intended to connect the workings with the Miller pit, as a provision for safety and ventilation.

The Harmony mines have been usually active, the output going to the new No. 3 mill completed in 1910. The products consist of ordinary concentrates with about 64 per cent iron and extra high grade concentrates with 71.4 per cent iron, the latter being used for making electrodes for arc lamps. The tailings from the mill also find application for road and concrete work. A complete description of this mill which contains many advanced features in the magnetic separation of iron ore has been given by H. Comstock,[1] Assistant General Manager of Witherbee, Sherman & Co.

The work in the Barton Hill mines has been mainly of development character, preparatory to their steady operation. From the new tunnel a raise has been excavated to the old Orchard pit encountering good ore all the way. For the treatment of the future mine output a new mill is in course of construction, the fourth erected by the company. The mill is designed for a capacity of 100 tons crude ore an hour. It is to be an all-steel structure with corrugated iron cover. The crushing department will be equipped with a 24 by 36 inch jaw crusher and two no. 5 Gates gyratory crushers from which the product will go to a storage bin of 1200 tons capacity. From the storage bin the ore passes to revolving screens making four sizes each of which is delivered to independent separators of the drum and belt types. These make three products, concentrates that go to the shipping bin, tailings to the stock pile, and middlings which are reground by rolls, sized and again separated. The power for driving the crushers and separators will consist of four motors of 150 h. p. each.

The Port Henry Iron Ore Co. obtained most of its product from the Clonan shaft in the southern part of the "21" ore body, but also hoisted some ore from the upper workings reached by the incline. The Welch shaft farther north contributed a small output.

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[1] The Iron Trade Review, Nov. 9, 1911, p. 825-29.

Cheever mine. The recently revived operations at this mine near Port Henry continued to afford a good output during the past year. The southern end of the old workings have thus far received most attention. Though no extensive bodies of rich ore have been found, a large quantity of material of concentrating grade has been developed, sufficient to assure a steady production for some time to come. The shipments are all in the form of concentrates, made in a local mill.

Some prospecting has been under way during the year on the northern continuation of the Cheever ore belt. The results of the work which was carried on by a Buffalo company have not been given to the public.

Lyon Mountain. The mines at Lyon Mountain were operated as usual for the supply of the Standish furnace.

Benson Mines. No production of ore was made by these mines last year. The results obtained with the old mill proved so unsatisfactory, that work was suspended and preparations started toward its replacement by a new structure. This is now in course of erection. The mill which is planned for two units will be first equipped for a single unit with a capacity of 1000 tons crude ore a day. The scheme of separation involves the use of dry magnetic belt and drum machines following the general plan adopted in the other Adirondack mills. A storage capacity of 10,000 tons of dried ore will be provided so as to insure continuous work during the winter season which is rather severe in that region. Power for the mines and mill is to be supplied from an independent hydro-electric station.

MINERAL PAINT

Under this title are included the natural mineral colors which require nothing more than grinding or washing in their preparation for the market. The raw materials found in the State that have been used for the purposes are iron ore, ocher, shale and slate. New York is also one of the leading producers of artificial pigments, specially those made from lead, but as the materials are derived from outside sources no account of them is taken in this place.

The Clinton hematite affords an excellent base for the manufacture of metallic paint and mortar color. The beds with a relatively high iron content are employed, as they possess the softness and uniformity of texture, as well as depth of color, which are generally sought for. The mines owned by C. A. Borst at Clinton, Oneida county, and those of the Furnaceville Iron Co., at Ontario, Wayne county, supply most of the ore for paint. The hematite from the former locality belongs to the oolitic variety and that sold to paint manufacturers carries about 45 per cent iron. The ore in Wayne county is of fossil character carrying about 40 per cent iron. The red hematite from St Lawrence county is also used for metallic paint.

The manufacturers of metallic paint and mortar colors in New York State include the Clinton Metallic Paint Co., of Clinton, the William Connors Paint Manufacturing Co., of Troy, and the Rossie Iron Ore Paint Co., of Ogdensburg. A large quantity of the Clinton hematite is shipped to points outside of the State for manufacture.

Both shale and slate are ground for paint, their color depending largely upon the amount and nature of the iron oxids present. When there is a large proportion of ferric oxid the shale and slate may be sold as metallic paint. At Randolph, Cattaraugus county, beds of green, brown and bluish shale occurring in the Chemung formation have been worked for paint purposes. The red shale from the base of the Salina formation has been similarly utilized in years past, having been obtained from a locality in Herkimer county. At Roxbury, Delaware county, a shale in the Catskill series was once employed. The red slate of Washington county, which belongs to the Cambric, is the principal source of pigments of this character at present. The Algonquin Red Slate Co. of Worcester, Mass., and A. J. Hurd's Sons of Eagle Bridge are producers of red slate pigment.

The ferruginous clay called ocher is of common occurrence, but is not now worked in the State. Sienna, a deep brown variety of ocher, is found near Whitehall.

The production of mineral paints in 1911 included 7237 short tons of metallic paint and mortar color valued at $68,870 and 1646 short tons of slate pigment valued at $12,864. The totals for 1910 were 8063 short tons of metallic paint and mortar color valued at $70,841 and 1400 short tons of slate pigment valued at $10,900. These quantities represent only the pigments manufactured within the State from local materials.

MINERAL WATERS

New York has held for a long time a leading position among the states in the utilization of mineral waters. The different springs, of which over two hundred have been listed as productive at one time or another, yield a great variety of waters in respect to the character and amount of their dissolved solids. There are some that contain relatively large amounts of mineral ingredients and are specially valuable for medicinal purposes; Saratoga Springs, Ballston Springs, Richfield Springs, Sharon Springs and Lebanon Springs are among the more noted localities for such waters. Numerous other springs are more particularly adapted for table use containing only sufficient mineral matter perhaps to give them a pleasantly saline taste. Both kinds of waters are generally carbonated and sold in small bottles.

Of late there has developed an important business in the sale of spring waters which can hardly be classed as mineral in the common acceptance of the word, but which are extensively consumed for office and family use in the larger towns and cities. Their employment depends upon their freedom from harmful impurities, in which feature they are generally superior to the local supplies. In so far as such waters are an article of commerce they may well be included in a canvass of the mineral water industry. They are usually distributed in large bottles or carboys in noncarbonated condition.

Character of mineral waters. Among the spring waters that contain mineral ingredients in appreciable quantity those characterized by the presence of alkalis and alkaline earth are the most abundant in the State. The dissolved bases may exist in association with the chlorin and carbon dioxid, as in the springs of Saratoga county, or they may be associated chiefly with sulfuric acid, as illustrated by the Sharon and Clifton springs.

The mineral waters of Saratoga Springs and Ballston are found along fractured zones in Lower Siluric strata, the reservoirs occurring usually in the Trenton limestone. They are accompanied by free carbon dioxid which, together with chlorin, sodium, potassium, calcium and magnesium, also exists in dissolved condition. The amount of solid constituents in the different waters varies from less than 100 to over 500 grains per gallon. Large quantities of table and medicinal waters are bottled at the springs for shipment to all parts of the country. The carbon dioxid which issues from the wells at Saratoga is likewise an important article of commerce.

The waters at Richfield Springs contain the elements of the alkali and alkaline earth groups together with sulfuric acid and smaller amounts of chlorin, carbon dioxid and sulfureted hydrogen. They are employed for medicinal baths as well as for drinking purposes. The springs issue along the contact of Siluric limestone and Devonic shales. Sharon Springs is situated to the east of Richfield Springs and near the contact of the Lower and Upper Siluric. Clifton Springs, Ontario county, and Massena Springs, St Lawrence county, are among the localities where sulfureted waters occur and are utilized.

The Oak Orchard springs in the town of Byron, Genesee county, are noteworthy for their acid waters which contain a considerable proportion of aluminum, iron, calcium and magnesium, besides free sulfuric acid.

The Lebanon spring, Columbia county, is the single representative in the State of the class of thermal springs. It has a temperature of 75° F. and is slightly charged with carbon dioxid and nitrogen.

Ordinary spring waters. The greater quantity of spring waters consumed in the State belongs to the nonmedicinal, noncarbonated class, represented by such springs as the Great Bear, Deep Rock, Mount View, Sun Ray, Chemung etc. The waters are obtained either by flowing springs or from artesian wells and are shipped in carboys or in tank cars to the principal cities where they are bottled and distributed by wagons among the consumers. The essential feature of such waters is their freedom from noxious impurities. This is generally safeguarded by the care exercised in the handling of the waters which are also regularly examined in the chemical and bacteriological laboratories.

Carbon dioxid. This gas is given off in quantity by some of the wells at Saratoga Springs, and its collection and storage for shipment constituted for many years an important industry at that place. Over 30 wells have been bored there for gas alone. The industry has now been discontinued by force of a legislative enactment; it was considered that the pumping of the wells for the production of the gas was detrimental to the other springs that were utilized solely for their waters. For some time the value of the natural gas secured for the wells exceeded that of the mineral water sales.

List of springs. The following list includes the names and localities of most of the springs in the State that are employed commercially, as shown by a canvass of the industry:

NAME	LOCALITY
Baldwin Mineral Spring	Cayuga, Cayuga co.
Coyle & Caywood	Weedsport, Cayuga co.
Diamond Rock Spring	Cherry Creek, Chautauqua co.
M. J. Spicer	West Portland, Chautauqua co.
Breesport Oxygenated Mineral Spring	Breesport, Chemung co.
Chemung Valley Spring	Elmira, Chemung co.
Chemung Spring Water Co	Chemung, Chemung co.
Lebanon Mineral Spring	Lebanon, Columbia co.
Monarch Spring Water Co	Matteawan, Dutchess co.
Mt Beacon Spring	Matteawan, Dutchess co.
Mount View Spring	Poughkeepsie, Dutchess co.
Ayers Amherst Mineral Spring	Williamsville, Erie co.
Elk Spring Water Co	Lancaster, Erie co.
Beauty Spring Water Co	Lyons Falls, Lewis co.
Cold Spring	New York Mills, Oneida co.
Lithia Polaris Spring	Booneville, Oneida co.
J. Wells Smith	Franklin Springs, Oneida co.
F. H. Suppe	Franklin Springs, Oneida co.
W. W. Warner	Franklin Springs, Oneida co.
Geneva Lithia Spring	Geneva, Ontario co.
Red Cross Lithia Spring	Geneva, Ontario co.
Crystal Spring	Oswego, Oswego co.
Great Bear Spring	Fulton, Oswego co.
J. Hagerty	Oswego, Oswego co.
Os-we-go Spring	Oswego, Oswego co.
Mammoth Spring	North Greenbush, Rensselaer co.
Shell Rock Spring	East Greenbush, Rensselaer co.
Massena Mineral Spring	Massena Springs, St Lawrence co.
Arondack Spring	Saratoga Springs, Saratoga co.
Artesian Lithia Spring	Ballston Springs, Saratoga co.
Chief Spring	Saratoga Springs, Saratoga co.
Coesa Spring	Saratoga Springs, Saratoga co.
Comstock Mineral Spring	Ballston Springs, Saratoga co.
Congress Spring	Saratoga Springs, Saratoga co.
Excelsior Spring	Saratoga Springs, Saratoga co.
Geyser Spring	Saratoga Springs, Saratoga co.
Hathorn Spring	Saratoga Springs, Saratoga co.
High Rock Spring	Saratoga Springs, Saratoga co.
Patterson Mineral Spring	Saratoga Springs, Saratoga co.
Quevic Spring	Saratoga Springs, Saratoga co.
Royal Spring	Saratoga Springs, Saratoga co.
Saratoga Seltzer Spring	Saratoga Springs, Saratoga co.
Saratoga Vichy Spring	Saratoga Springs, Saratoga co.
Star Spring	Saratoga Springs, Saratoga co.
Chalybeate Spring	Sharon Springs, Schoharie co.
Eye Water Spring	Sharon Springs, Schoharie co.
Gardner White Sulphur Spring	Sharon Springs, Schoharie co.
Sulphur-Magnesia Spring	Sharon Springs, Schoharie co.
Red Jacket Spring	Seneca Falls, Seneca co.
Pleasant Valley Mineral Spring	Rheims, Steuben co.
Setauket Spring	Setauket, Suffolk co.
Elixir Spring	Clintondale, Ulster co.
Sun Ray Spring	Ellenville, Ulster co.
Vita Spring	Fort Edward, Washington co.
Briarcliff Lodge Association	Briarcliff Manor, Westchester co.
Gramatan Spring Water Co	Bronxville, Westchester co.

Production. The reports received from the mineral water trade in 1911 showed sales of 8,923,628 gallons valued at $756,147. The number of springs contributing to the production was about 40. In the preceding year the sales amounted to 8,432,672 gallons valued at $675,034, reported by 46 springs. The value of the water is estimated at the spring water localities and does not include the cost of bottling. No account is made of the waters used in hotels, sanatoriums etc., run in connection with the springs, though this is an important item in the business in some places.

A comparison of the sales reported for a number of years back shows that the demand for the higher priced carbonated waters apparently has fallen off, but this decrease has been more than counterbalanced by the increased consumption of the ordinary spring waters supplied for office and family use.

Saratoga Springs. The plans for the creation of a State reservation which is to include practically all the springs hitherto employed for the commercial production of mineral waters and carbon dioxid have begun to take definite form. The commission empowered to effect the transfer of the property from private to State ownership had taken over at the close of the year the following springs: Hathorn (nos. 1, 2, 3), Coesa or Carlsbad, Champion, Red, Patterson, Putnam, Star, Governor, High Rock, Seltzer, Magnetic and Peerless, Victoria, Geyser, Adams and Congress. Those not included in the transfer at that time were the Arondack, Vichy, Chief, Excelsior and Quevic. Of the springs on the State reservation a few were utilized for commercial production by Hathorn & Co., under lease.

NATURAL GAS

The natural gas resources of the State are undergoing steady development, the production being little influenced by the varying trade conditions that affect other branches of mining. The supply, though it has increased markedly of late years, falls far short of meeting the requirements in the territory around the gas fields, and is helped out by importations from other states, chiefly Pennsylvania. Natural gas has been in use locally for nearly a century; there is a record of its employment for fuel and light as far back as 1825 at which time wells were in operation in Chautauqua county for the supply of natural gas to households.

The industry of supplying gas for general consumption first assumed importance, however, with the development of the oil districts in Allegany and Cattaraugus counties, the gas being recovered as a by-product and sold to distributing companies who piped it to the towns and villages in the surrounding section. In the nineties of the last century exploration for gas was carried on actively all through the western part of the State and some new fields were discovered, notably in the section along the shore of Lake Ontario. A little later an important field was opened in Erie county, east of Buffalo. The gas pools were encountered in the Medina sandstone and led to the exploration of this formation along the dip in southern Erie and northern Chautauqua counties where some very productive wells have been opened at depths of 2000 feet or more.

Altogether there are 16 counties in the State that produce natural gas. The principal fields are found in Erie, Genesee, Chautauqua, Allegany and Cattaraugus counties. Outside of these the pools are of subordinate extent and importance, so far as they have been tested, and are scattered rather sparsely over the western section of the State, from Lake Erie and the Niagara river to the east end of Lake Ontario. Exploration of the rocks in eastern New York has been unsuccessful in locating valuable pools.

The supply of natural gas is derived from several geologic horizons, from the Potsdam sandstone in the Cambric to the Chemung strata at the top of the Devonic. The more productive formations include the Trenton limestone of the Lower Siluric, the Medina sandstone of the Upper Siluric, and the Portage and Chemung shales with interbedded sandstones belonging to the Devonic. With few exceptions the gas pools now producing occur in one or another of these formations.

The oil fields of Allegany and Cattaraugus counties have contributed, and still do contribute, considerable quantities of gas. The pools are found in sandstones at different horizons in the Devonic, such as the Bradford, Kane, and Elk "sands" of the Chemung. Some of the supply is consumed in the gas engines for pumping the oil, and the remainder is used for lighting and heating in the local towns or is piped to Buffalo. The distribution of the gas is mainly in the control of a few companies, like the Empire Gas and Fuel Co. of Wellsville, the Producers Gas Co. of Olean, and the United Natural Gas Co. of Oil City, Pa. Some of the local towns supplied from the fields are Olean, Andover, Wellsville, Friendship, Hornell and Geneseo. In the northwestern part of Cattaraugus county there is a small field of which Gowanda is the center and which extends across the border into Erie county. The gas is said to occur in the

Marcellus and Onondaga formations of the Middle Devonic. The output is distributed by the Gowanda Gas Co. for use in Gowanda. Explorations have been under way recently in northern Cattaraugus county between Gowanda and Cattaraugus where pools are reported at depths from 2500 to 3300 feet in what is supposed to be the Medina sandstone.

In Chautauqua county the productive area comprises a belt bordering Lake Erie from Silver Creek southwest to the Pennsylvania state line. Until quite recently the supply has been obtained from wells a few hundred feet deep in the Portage and Chemung beds and the individual output was small, sufficing only for a few families at most. Deep drilling during the last few years has resulted in the discovery of more productive pools, lying at depths from 1900 to 2300 feet in what is considered Medina sandstone. Some very large flows have been encountered in the vicinity of Silver Creek, Dunkirk, Forestville, Sheridan and Westfield. These wells are mainly owned by local companies who sell the output in the neighboring towns and villages. The principal operators include the Frost Gas Co., Silver Creek Gas and Improvement Co., South Shore Gas Co., and Welch Gas Co. During the past year the United Natural Gas Co. has been engaged in exploration in the town of Arkwright east of Fredonia and is reported to have encountered gas in quantity at depths around 2100 feet.

Erie county contains several fields. A few wells have been put down within the limits of Buffalo. East Aurora, Collins, North Collins, Angola and Springville in the southern part are centers of a more or less active industry. Within the last 15 years a field has been opened east of Buffalo in the towns of Cheektowaga, Amherst, Lancaster, Clarence, Alden and Newstead, which for some time has been the most productive in the State. The gas is found in the Medina sandstone at depths of from 1200 to 1600 feet, and the wells have proved quite persistent producers. It is transported in pipe lines to Buffalo, Tonawanda, Batavia, Lancaster, Depew, Honeoye Falls and other towns in the vicinity. There are over 200 productive wells in the field.

In Genesee county a prolific field has been developed at Pavilion during the last five years. The gas is found in the same horizon as in eastern Erie county, at depths of about 1700 feet. The Pavilion Natural Gas Co. and the Alden-Batavia Natural Gas Co. are the chief operators in the field and supply the gas to Pavilion, Leroy and Batavia.

In Wyoming county a few wells are in operation at Attica; in Livingston county at Caledonia, Avon and Lima; and in Ontario county in the towns of East Bloomfield and West Bloomfield. Farther east in Onondaga county there are wells at Baldwinsville and Phoenix which supply gas for local use. The pools are found in the Trenton shales and limestone. Oswego county marks the eastern limit of the productive territory, with wells at Pulaski and Sandy Creek.

Production. The value of the natural gas production during the last 4 years is shown in the accompanying table which is arranged to show also, so far as practicable, the contributions from the principal fields. The returns for the year 1911 indicated a total of $1,547,077, against $1,045,693 for 1909, an increase of approximately 50 per cent in the two years. The quantity of gas produced was approximately 5,127,571,000 cubic feet as compared with 4,815,643,000 cubic feet in 1910 and 3,825,215,000 cubic feet in 1909. These amounts include estimates for some of the smaller producers who have no meters attached to their mains, but they are believed to be close approximations of the actual production. The average value of the gas was 30 cents a thousand, against 29 cents and 27 cents a thousand respectively in the preceding years.

Production of natural gas

COUNTY	1908	1909	1910	1911
Allegany, Cattaraugus..	$264 736	$282 964	$337 427	$402 931
Chautauqua..........	153 019	174 597	202 754	222 023
Erie [1]...............	451 869	461 531	717 038	813 279
Livingston [2]...........	54 083	59 888	60 997	73 357
Onondaga............	13 837	12 310	12 733	12 972
Oswego...............	12 800	14 402	14 783	14 913
Wyoming [3]............	37 431	40 001	65 967	7 602
Total............	$987 775	$1 045 693	$1 411 699	$1 547 077

[1] Includes all the output in Genesee county for 1911 and a part of it for the preceding years.
[2] Includes also Seneca, Schuyler, Steuben, Ontario and Yates.
[3] Includes Niagara and also some of Genesee except for 1911.

The reports for 1911 covered a total of 1403 productive wells.

A comparison of the figures shows that Erie county leads all others in quantity and value of output. Its contribution including also that of Genesee county, amounted last year to 2,444,721,000 cubic feet valued at $813,279. There were 342 productive wells in the two counties.

The production given under Allegany and Cattaraugus counties included mainly the gas collected from oil wells, but there was a small output also from fields in the northern parts of the two counties where no oil is produced. The combined output taken from the reports of the pipe-line companies and the individual producers amounted last year to 1,600,317,000 cubic feet valued at $402,931, from a total of 766 wells.

The wells in Chautauqua county made an output of 804,713,000 cubic feet valued at $222,023. The principal part of the supply came from the deep wells which have been put down in the last few years in the belt along Lake Erie.

Genesee county has shown the largest relative increase in production during the past years, but the figures are included with those of Erie county.

PETROLEUM

The anticipated effects of the recent decline in crude oil prices were very manifest during 1911, at least in the New York field. There was less activity in exploration than for many years and with the comparatively poor record of new drilling in 1910, the productive conditions were most unfavorable. The maintenance of the local industry for a long time has been the small increments of yield obtained by redrilling old territory, for which the main incentive existed in the high market value of the local product. The recent decline, amounting to over 50 cents a barrel, practically put an end to such developments.

The total production in 1911, as reported by the pipe-line companies operating in the New York oil region, amounted to 915,314 barrels. The total for the preceding year was 1,073,650 barrels, showing a falling off of 158,336 barrels, or 15 per cent. The output in 1909, which was a year of good prices on the whole, amounted to 1,160,402 barrels. The value of the product last year was $1,198,868, or an average of $1.31 a barrel, against $1,458,194, an average of $1.36 in 1910, and $1,914,663, an average of $1.65 in 1909.

The production of oil during the last two decades is shown in the accompanying table. The figures for the years 1892–1903 have been compiled from the annual volumes of the *Mineral Resources,* while those for subsequent years are based on the reports received from pipe-line companies who transport the oil to the refiners. The following companies operate pipe lines in the New York field: The Allegany Pipe Line Co., Columbia Pipe Line Co., Union Pipe Line Co., and Fords Brook Pipe Line Co., of Wellsville; Vacuum Oil Co., of Rochester; New York Transit Co., of Olean; Emery Pipe Line Co., Kendall Refining Co., and Tide Water Pipe Co., Limited, of Bradford, Pa.

Production of petroleum in New York

YEAR	BARRELS	VALUE
1892	1 273 343	$708 297
1893	1 031 391	660 000
1894	942 431	790 464
1895	912 948	1 240 468
1896	1 205 220	1 420 653
1897	1 279 155	1 005 736
1898	1 205 250	1 098 284
1899	1 320 909	1 708 926
1900	1 300 925	1 759 501
1901	1 206 618	1 460 008
1902	1 119 730	1 530 852
1903	1 162 978	1 849 135
1904	1 036 179	1 709 770
1905	949 511	1 566 931
1906	1 043 088	1 721 095
1907	1 052 324	1 736 335
1908	1 160 128	2 071 533
1909	1 160 402	1 914 663
1910	1 073 650	1 458 194
1911	915 314	1 198 868

The average quotations for crude oil from the Appalachian districts were lower in 1911 than at any time since 1901. The prices of Pennsylvania crude, which are taken as the basis for rating the New York output, were $1.30 a barrel at the opening of the year and remained unchanged until the last week in December when they advanced to $1.35. The outlook for the current season would appear more favorable, as the tendency in the early months was toward a higher level.

The records for the year showed that 195 new wells were completed, as compared with 283 wells in the preceding year, and 457 wells in 1909. The increment of production from the new wells amounted to 201 barrels a day, while in 1910 it was 368 barrels and in 1909 it amounted to 715 barrels. Of the number of wells given 59 were dry, as compared with 61 and 32 respectively for the two preceding years.

The oil pools found in the State constitute the northern extension of the Appalachian field which reaches its main development in Pennsylvania, Ohio and West Virginia. They underlie small areas in Cattaraugus, Allegany and Steuben counties near the Pennsylvania border. The first well was drilled in Cattaraugus county in 1865, and Allegany county began producing about 1880. The oil is found in fine-grained sandstones of dark color belonging to the Chemung formation of the upper Devonic. In Cattaraugus county the productive area embraces about 40 square miles, mostly in Olean, Allegany and Carrolton townships. The pools of which the principal ones are the Ricebrook, Chipmunk, Allegany and Flatstone, occur at several horizons from 600 to 1800 feet below the surface. The oil district of Allegany county extends across the southern townships of Clarksville, Seneca, Wirt, Bolivar, Alma, Scio and Andover and is divided into several pools that are considered to be more or less independent. The Bolivar, Richburg and Wirt pools have been most productive. The oil is found at depths of from 1400 to 1800 feet. The Andover pool lies partly in the town of West Union, Steuben county, and is accountable for the production in that section. The reports of the *Mineral Resources* covering the year 1910 showed a total of 10,995 productive wells in the State, of which number Allegany county had 7859, Cattaraugus county 2917 and Steuben county 219. Practically all the wells are pumped and the average yield is less than one-third of a barrel a day.

There has been a great deal of exploration outside the districts mentioned, but up to the present time has not led to any positive additions to the productive area. Some of the more interesting and promising developments have been in northern Allegany county. A discovery of oil was reported a few years since in the town of Granger on the Livingston county border, considerably north of the other pools, and about 30 wells were drilled as a test. Some of these flowed under natural pressure, but they soon gave out, yielding less than 3000 barrels altogether. In the last year or two another section near Swain, town of Grove, has been under exploration. The original discovery was reported on the Fred Bennett farm where oil and gas were encountered in a well put down to 740 feet depth. Some other holes in the same vicinity were dry. Recently drilling has been under way on the Harman place, and two productive wells are reported to have been brought in of which the first produced from 5 to 6 barrels a day. The second was dry when drilled, but began to flow after having been "shot." The oil is said to be of a dark, heavy quality.

PYRITE

Pyrite is obtained commercially in St Lawrence county. The mines of that section have been worked intermittently for many years but have come into prominence only of late, largely as the result of the systematic operations carried on by the St Lawrence Pyrite Co. The property of this company is situated at Stellaville near Hermon, and comprises a number of mines that have been more or less extensively developed, a large concentrating plant, and other equipment including the branch railroad from Hermon to De Kalb Junction which it built to secure an outlet for its product. The shipments are in the form of concentrates which are sold to sulfuric acid makers.

In addition to the Stellaville mines, the Cole property near Gouverneur has been a producer during the last two years, having been reopened in 1910. It is worked under lease by the Hinckley Fibre Co., which uses the output in crude form for the manufacture of sulfite pulp at its plant at Hinckley, Oneida county.

The employment of the crude low-grade ore for direct conversion of the sulfur into sulfurous acid to be used in the sulfite pulp process is a new development which if permanently successful, as it appears likely to prove from present indications, may have important consequences for the Adirondack mining industry. The output of sulfite fiber by the mills in that section is reported as about 900 tons daily for which 135 tons of commercial sulfur are imported at an average cost of $3300. To supply the equivalent amount of sulfur from pyrite would require from 400 to 600 tons of the usual grade of St Lawrence county ore, or say 150,000 tons a year. According to information privately communicated to the writer, there is an important economy in the use of the pyrite whenever it can be laid down at the mill at a fair price. In the case of such low-grade ores, its uses, however, necessitate special apparatus and methods which have been the subject of extended investigation; that success, to a certain degree at least, has attended the experiments seems to be evidenced by the continued shipments from the Cole mine.

Pyrite is rather abundantly distributed in the Adirondack region, and is represented in larger quantity in association with the Grenville series of gneisses, schists and crystalline limestones. The principal deposits thus far found occur in the belts of these rocks, which are regarded as metamorphosed sediments, on the western border in St Lawrence and Jefferson counties. One large belt extends from near Antwerp, Jefferson county, across Gouverneur, De Kalb and Hermon townships of St Lawrence county, a distance of over 40 miles. It is the same belt which carries the red hematite ores of that region. The pyrite is disseminated through the schists and gneisses, but here and there it occurs segregated in bands or lenses so as to constitute mineable deposits, though of rather low-grade character. The bodies are arranged in conformity with the major structural features of the county rocks, so far as can be determined, having usually a northeast-southwest strike and a northerly dip as are prevalent throughout the region. They show local modifications in the way of folding, swells and pinches and were no doubt accumulated before the final period of regional compression which has affected the wall rocks.

The ore as mined consists normally of a granular aggregate made up of crystals and irregular particles of pyrite distributed through a gangue of which quartz is the chief component. The texture and grade of the ore is quite variable. Considerable masses of practically pure pyrite are found as an intergrowth of large-sized crystals, but the chief part of the output is represented by a mixture of medium to fine-grained pyrite showing no crystal development, with fairly large amounts of gangue materials. Besides quartz the accompanying minerals include hornblende, biotite, feldspar and alteration products of chloritic nature. Zinc blende and chalcopyrite are found occasionally in small amounts in the ore.

In some parts of the belt pyrrhotite occurs as an associate of the pyrite or in separate bodies of closely related features. It is found for instance at High Falls or Pyrites in distinct shoots though in the same mineralized zone with the pyrite. It has not been considered, hitherto, of any economical value, yet recent progress in the use of low-grade sulfides may be regarded as affording some prospect for its future industrial employment. The sulfur content is naturally lower than that of the pyrite, the theoretic amount being a little under 40 per cent and the average of the usual grade of material probably not over 25 per cent. The pyrrhotite gives a slight reaction for nickel.

The mines at Stellaville operated by the St Lawrence Pyrite Co. are opened on a parallel series of deposits, of which the largest is known as the Stella. A second important deposit, the Anna, is found in the footwall, 1600 feet to the southeast, and others occur in the interval. The ore carries from 15 to 40 per cent of sulfur, with an average probably between 25 and 30 per cent. A small quantity is marketed as hand-cobbed ore or "spalls" with about 33 per cent sulfur, but the main product consists of mill concentrates with a content of 40 per cent or more. The concentrates are shipped to acid burners in the East. Though of lower sulfur content than the imported ores, they are a desirable material for acid-making on account of their freedom from arsenic and other injurious impurities. A comprehensive account of the Stellaville mines and their equipment has been contributed by Felix A. Vogel to volume 16 of the *Mineral Industry*.

The Cole mine at Gouverneur is based on a large outcropping deposit that was first worked as an open cut. The early development was carried out by the Adirondack Pyrite Co., later succeeded by the American Pyrite Co. The latter company ceased work in 1907 and dismantled the mining and milling plant. The property remained idle until the Hinckley Fibre Co. took it over in 1910. As shown in the present workings the ore lies in two parallel bodies separated by 15 or 20 feet of quartz rock. The lower deposit is about 15 feet thick and dips 40° to the northwest. It was first worked by open-cut methods and afterwards through an inclined shaft. The present supply of ore is taken mainly from the overlying body, which at the point of attack shows a thickness of about 50 feet and which is being developed through a raise from the lower workings. The present development of the mine is insufficient to afford much information in regard to the actual relations of the ore bodies and their extent. The crude ore as shipped carries from 25 to 40 per cent sulfur, with an average probably of 30 per cent or slightly less.

The deposits at Pyrites which were taken over by the Oliver Mining Co. about five years ago have remained inactive. They consist of a series of lenses that strike northeast and dip northwest at an angle of 15°. Their line of outcrop extends across the Grasse river under which there are workings reached from an island in the river. They have been explored in depth by the diamond drill but nothing can be stated as to the results beyond the fact that the ore appears to be persistent.

Besides the deposits mentioned that have been developed as mines, there are many prospects and exposures of pyrite in the metamorphic region of St Lawrence and Jefferson counties. Some of the better known localities are on the Alexander Farr farm, two and a half miles northeast of Bigelow; on the George Styles farm, one and a half miles west of Bigelow; the farm of S. Hendricks, one mile south of Bigelow; and that of S. Hockens, seven miles west of Rensselaer Falls. Near Antwerp pyrite is found in the vicinity of the Dixon and Old Sterling iron mines. As has been noted by C. H. Smyth, jr, the hematite deposits of that section are often accompanied by bodies of pyrite in the adjoining wall rocks. Their distribution may afford a useful clew to exploration for the latter. There is an extensive belt of pyrite and pyrrhotite in the vicinity of Ox Bow.

The zinc ores near Edwards which are under development carry more or less pyrite intermixed with the blende. The pyritous ores are being reserved for mill treatment by which it is intended to make a pyrite concentrate as a by-product.

SALT

The salt industry throughout the State was practically unchanged last year. There were no additions to the list of producing plants. The output continued at about the rate established in the preceding year or two, and the market conditions, so far as prices were concerned, were almost stationary, at least showing no definite tendency toward recovery from the previous low levels. The selling prices of the various grades of evaporated salt have undergone a marked decline of late years, and it is doubtful if any further extensive reduction could take place without reacting injuriously upon that branch of the industry. The only real gains in the production recently have come from the rock salt mines and from the wells whose output of brine is consumed without evaporation for manufacture of soda products.

The total quantity of salt taken from the mines and wells during the year was 10,082,656 barrels of 280 pounds. This was a slight decrease from the total of 10,270,273 barrels reported for 1910, the largest ever recorded in the State, but exceeded the output of any other year. The actual decline was thus 187,617 barrels, or a little less than 2 per cent of the gross amount. Converted to a tonnage basis the product in 1911 was equivalent to 1,411,572 short tons against 1,437,838 short tons for the year 1910.

The value of the salt production, as fixed by the reports from the companies, amounted to $2,191,485, as compared with $2,258,292, the value reported for the year 1910. These figures are based on the values at the mines or works, exclusive of costs of package. The average was 21.7 cents a barrel, against 22 cents a barrel in 1910, 23.3 cents in 1909, 23.7 cents in 1908 and 25 cents in 1907. Prices have thus fallen steadily for a number of years. It is to be noted, however, that the average values as given are reduced considerably by the inclusion of salt used in the form of brine for alkali manufacture. Since this salt is not marketed as such, and is not even evaporated, it is given only a nominal valuation, representing practically the mere cost of pumping. The production of this brine is confined to a single company, the Solvay Process Co., which has a number of wells in the town of Tully, Onondaga county, whence the brine is carried through a pipe line to the alkali works near Syracuse.

The accompanying tables give the statistics of salt production for recent years. For the years 1910 and 1911 the output is given according to grades, so far as the classification could be made without revealing the individual figures. The grades depend upon methods of manufacture and purposes for which the salt is used. Rock salt and salt in brine consumed by the alkali industry appear in the last item of the detailed tables which also includes small quantities of evaporated salt not specially classified in the returns. The evaporated salt is chiefly marketed under the grades of common fine, table and dairy, common coarse, common solar, and packers salt. Table and dairy salt includes the finest grades of artificially evaporated specially prepared for the table and for butter and cheese making; it brings the highest market price. Under common fine are listed the other grades of fine, artifically evaporated salt that are not specially prepared. Common coarse represents the coarser product from artificial evaporation. Coarse solar salt is made by evaporation of brine in shallow pans exposed to the sun's heat. This process is employed only by the manufacturers in Syracuse and vicinity, and can be carried on, of course, only in the summer months. Packers salt includes the product sold to meat packers and fish salters.

Production of salt by grades in 1910

GRADE	BARRELS	VALUE	VALUE PER BARREL
Common fine[1]	1 322 015	$378 547	$ .28
Common coarse	243 928	81 233	.33
Table and dairy	1 258 089	611 271	.49
Coarse solar	439 780	129 295	.29
Packers	37 935	13 277	.35
Other grades[2]	6 968 526	1 044 669	.15
Total	10 270 273	$2 258 292	$ .22

[1] Common fine includes a small amount of common coarse.
[2] Include rock salt, salt in brine used for soda manufacture, and small amounts of brine salt for which the uses were not specified in the returns.

Production of salt by grades in 1911

GRADE	BARRELS	VALUE	VALUE PER BARREL
Common fine[1]	1 143 886	$328 127	$ .29
Common coarse	285 407	96 968	.34
Table and dairy	1 312 000	629 581	.48
Coarse solar	434 414	131 247	.30
Packers	40 721	11 402	.28
Other grades[2]	6 866 228	994 160	.14
Total	10 082 656	$2 191 485	$ .217

[1] Common fine includes a small quantity of common coarse.
[2] Include rock salt, salt in brine used for soda manufacture, and small amounts of brine salt for which the uses were not specified in the returns.

The output in 1911 was contributed by 30 mines and works distributed among six counties of the State. Onondaga county was represented by the largest number of producers, having 20 in all. Livingston county was represented by 3, of which 2 were rock salt mines, the only ones now active. Schuyler, Tompkins and Wyoming counties each had 2 producers, and Genesee county which completes the list had 1.

Production of salt in New York since 1887

YEAR	BARRELS	VALUE
1887	2 353 560	$936 894
1888	2 318 483	1 130 409
1889	2 273 007	1 136 503
1890	2 532 036	1 266 018
1891	2 839 544	1 340 036
1892	3 472 073	1 662 816
1893	5 662 074	1 870 084
1894	6 270 588	1 999 146
1895	6 832 331	1 943 398
1896	6 069 040	1 896 681
1897	6 805 854	1 948 759
1898	6 791 798	2 369 323
1899	7 489 105	2 540 426
1900	7 897 071	2 171 418
1901	7 286 320	2 089 834
1902	8 523 389	1 938 539
1903	8 170 648	2 007 807
1904	8 724 768	2 102 748
1905	8 575 649	2 303 067
1906	9 013 993	2 131 650
1907	9 657 543	2 449 178
1908	9 005 311	2 136 736
1909	9 880 618	2 298 652
1910	10 270 273	2 258 292
1911	10 082 656	2 191 485

The large number of producers in Onondaga county is incident to the solar salt industry which is carried on extensively around Syracuse. The brine used by the solar evaporating works or salt yards is stored in glacial gravels and is pumped and distributed by central plants. The principal supply comes from the old Onondaga Salt Springs Reservation that was sold by the Indians to the State in 1788. The manufacture of salt was placed under State control in 1797 from which time complete records of the industry are available. At one time artificial evaporation was extensively practised but this has been given up almost entirely in recent years with the increased competition from other districts. The solar salt is sold through the agency of the Onondaga Coarse Salt Association.

With the exception of the salt made at Syracuse the entire production is obtained from the deposits of rock salt which are found in the Salina formation, a succession of shales and limestones with intercalated beds of gypsum and rock salt. The Salina strata outcrop in an east-west belt across the State from Albany county to the Niagara river and are represented by a smaller separate area in southeastern New York. Well tests indicate that the salt deposits are restricted to the western section of the main belt beginning in Madison county; east of there the strata diminish in thickness to such an extent as to preclude their existence. They are encountered only at a depth of 1000 feet or more where there has been sufficient cover to protect them against solution by ground waters. As the whole stratified series has a dip uniformly toward the south the mines and wells are all located on the southern side of the outcrop which lies about on the line of the forty-third parallel. The dip averages 40 or 50 feet to the mile. The most easterly point where rock salt has been found is at Morrisville, Madison county. Between that place and Lake Erie it has been shown to exist in almost all of the middle tier of counties.

The exploration of the rock salt beds dates from 1878 when a well bored for oil near Wyoming, Wyoming county, encountered 70 feet of salt at 1270 feet from the surface. Discoveries were subsequently made at Warsaw, Leroy, Rock Glen, Batavia and numerous places in Livingston, Wyoming and Genesee counties. Practically the whole valley of Oatka creek, from Leroy to Bliss and the Genesee valley south of Monroe county has been found to be salt-bearing. The region is now the most productive in the State. Livingston county has the largest annual output which is contributed by the two rock salt mines at Retsof and Cuylerville owned respectively by the Retsof Mining Co. and the Sterling Salt Co., and by the evaporating plant of the Genesee Salt Co. at Piffard. The other companies now active in this section include the Leroy Salt Co., of Leroy; the Rock Glen Salt Co., of Rock Glen; and the Worcester Salt Co., of Silver Springs.

In Schuyler county salt is obtained around Watkins. The Glen Salt Co. sank the first well there in 1893 and encountered a deposit at 1846 feet depth. The plant is now operated by the International Salt Co. The Watkins Salt Co. also has works at this place.

A well drilled at Ithaca, Tompkins county, in 1885 passed through seven beds of salt aggregating 248 feet in thickness at depths below 2244 feet from the surface. The discovery was followed by active developments at Ludlowville in 1891 by the Cayuga Lake Salt Co., and at Ithaca in 1895 by the Ithaca Salt Co. The plants were taken over in 1899 by the National Salt Co., which was merged in 1905 into the International Salt Co. The Remington

Salt Co. later erected a plant at Ithaca which is now in operation, obtaining its salt from three wells at a depth of about 2100 feet.

The Solvay Process Co. derives its supply of brine from a number of wells located in the town of Tully, 20 miles south of Syracuse. The brine is carried in pipe line to the works at Solvay.

In Erie county rock salt has been found at Eden Valley, Springville, Perry and Gowanda, but there is no output at present in that county. Among the localities where discoveries have been made may be mentioned Vincent and Naples, Ontario county; Dundee, Yates county; Seneca Falls, Seneca county; and Aurora, Cayuga county. None of these deposits are worked. A well put down in 1909 in the town of Burns, Allegany county, is reported to have passed through 75 feet of clean unbroken salt at 3050 feet depth.

SAND AND GRAVEL

The production of sand and gravel for use in engineering and building operations, metallurgy, glass manufacture, etc., is an important industry involving a very large number of individual operations. The building sand business is specially extensive as there are deposits suitable for that purpose in every section of the State, and nearly every town or community has its local source of supply. Such sand, of course, possesses little intrinsic value. The deposits of glass sand and molding sands are more restricted in their distribution and their exploitation is the basis of a fairly stable industry; certain molding sands are even shipped to distant points, as in the case of those obtained in the Hudson river region.

The sand and gravel beds of the State are mainly of glacial origin, as the whole territory within the limits of New York, in common with the northern section of the United States east of the Rocky mountains, was invaded by the Pleistocene ice sheet which removed all the loose material accumulated by previous weathering and erosion, and left in its retreat a mantle of transported boulders, gravels, sands and clays. In places these accumulations have the character of unmodified drift or morainal accumulations in which the materials are more or less intermixed, and are then of little industrial value. But more generally the deposits show a sorted stratiform arrangement due to their having been worked over by the glacial streams and lakes. Such is the condition in many of the larger valleys like those of the Hudson, Champlain and Genesee where the sands, gravels and clays occur separately in terraced beds extending far above the present water level. Later water action may have effected a beneficial re-sorting of the materials as instanced by the beach sands of Long Island and some of the lakes in the interior of the State.

A measure of the importance of the sand and gravel industry may be had from the accompanying table which, however, lacks something in the way of completeness and accuracy. The figures relating to the molding sand production are believed to be a close approximation to the actual totals, but those for building sand and gravel may vary considerably from the true quantities, perhaps understating them by as much as 25 per cent. The building sand operations are so widely scattered and in many sections carried on in such haphazard or fugitive manner that it is extremely difficult to cover them all in a statistical canvass.

Production of sand and gravel

MATERIAL	1909	1910	1911
Molding sand	$437 402	$424 015	$420 780
Core and fire sand	30 230	33 709	27 484
Building sand	*b*	1 016 598	*c* 750 000
Other sand *a*	*b*	65 835	*c* 50 000
Gravel	*b*	589 551	479 103
Total	....	$2 129 708	$1 727 367

a Includes glass sand, filter sand, engine and polishing sand.
b Statistics not collected.
c Partly estimated.

Molding sand. The use of sand for the casting of metals calls for a large supply of special grades which have a rather restricted distribution, compared with building sands, and consequently greater value.

In New York there are two main areas in which good molding sands occur: (1) on the lands bordering the Hudson river from Orange county to Saratoga county; (2) in Erie county. The sand is found in shallow beds immediately beneath the sod and often covers extensive tracts. In the Hudson river region, which is by far the most important, beds 8 inches thick may be worked if convenient to transportation. From this they range up to 7 or 8 feet thick, though usually the finer grades occur in relatively thin deposits. The sand is graded roughly according to size, which varies from extremely fine sand that will pass through a 100 mesh screen to rather coarse gravel. The business of digging and shipping the sand is mainly conducted by a few large companies who operate in several places and are able to furnish all the grades in demand by foundries.

The production of molding sand in 1911 amounted to 476,014 short tons valued at $420,780, or a little more than in 1910 when the total was 471,351 tons valued at $424,015. The greater part of the output came from the Hudson river region, which contributed altogether 435,868 short tons with a value of $388,561. The counties represented in that section included Albany, Dutchess, Greene, Orange, Rensselaer, Saratoga and Schenectady. The counties in other sections that reported a production were Cayuga, Chautauqua, Erie, Essex, Livingston and Queens.

Core sand used in connection with molding sand for the cores of castings is chiefly produced in Erie and Oneida counties. The product is listed with fire sand, the combined production of the two kinds amounting last year to 49,900 short tons valued at $27,484.

Glass sand. Sand for glass manufacture is obtained from the beach sands of Oneida lake and Long Island. The crude sand undergoes purification by washing to remove the clay, mica, organic matter, etc. The manufacture of window glass was once an important industry in the district around Oneida lake where there are extensive deposits of very fine sand, but it has succumbed to competition with the factories situated in the natural gas region of Pennsylvania and the West. At present the product is shipped elsewhere for manufacture. A total of 20,821 short tons of glass sand valued at $16,000 was reported from the Oneida and Queens counties last year.

Building sand. The use of sand and gravel in building and engineering work calls for enormous quantities of these materials and is the basis of a productive industry that is carried on more or less actively in nearly every county of the State. The business is purely local, as the towns and villages are well supplied with deposits close at hand. The value of the materials is mainly represented in the cost of excavation.

A complete census of this branch of the sand industry would entail labor and expense incommensurate with the value of the results, and therefore nothing more has been done than to arrive at a basis for an approximate estimate. The combined value of the sand and gravel produced in 1911 is placed at $1,229,103, against a value of $1,606,149 in 1910. The quantity of sand was approximately 2,900,000 cubic yards and of gravel 1,013,470 cubic yards, as compared with 3,838,976 cubic yards of sand and 1,037,026 cubic yards of gravel produced in 1910. Nassau county from which much of the sand used in building operations in New York is obtained, contributed alone a total of 1,874,837 cubic yards of sand and 659,106 cubic yards of gravel last year.

SAND-LIME BRICK

The manufacture of sand-lime brick last year was somewhat larger than usual. Five companies reported as active and contributed a total of 15,178,000 bricks with a value of $92,064. This was but little short of the record production which was reported in 1907 and which amounted to 16,610,000 valued at $109,677. The outturn in 1910 was 14,053,000 with a value of $82,619. The selling price of the brick, fixed at the yard, averaged $6.05 a thousand last year, against $5.88 a thousand in 1910.

The following were the active plants: Composite Brick Co., Rochester; Dyett Sand-Lime Brick Co., Port Jefferson; Buffalo Sandstone Brick Co., Buffalo; Paragon Plaster Co., Syracuse; Granite Brick Co., Glens Falls.

The Grant Brick Co. of Brooklyn and the Sandstone Brick Co. of Schenectady reported as active in 1910 but did not manufacture last year.

STONE

The quarrying of stone and its preparation for the varied requirements of building, engineering construction, etc., hold a prominent place in the industrial activities of the State, and the value of the annual contribution ranks second only to that of clay among mineral materials. No other mineral industry includes so many individual enterprises or is so widely represented in the different sections. The resources are abundant and varied, comprehending all the principal varieties known to the trade. The greater number of quarries, however, are opened in the limestones and sandstones and supply material chiefly for engineering work, highway improvement and such purposes which do not entail any considerable amount of elaboration previous to shipment. In the development of the building, monumental and ornamental branches the local industry has not attained the relative importance that it deserves by reason of the natural wealth of materials adapted to those uses and the advantages for marketing; herein lies, it would appear, the principal field for future enterprise.

The statistics of production which have been collected from year to year show that the industry in general remains practically stationary; in fact lately it has taken a downward trend, falling below the average level of earlier years. This has been due in part to the recent business reaction that has affected practically all industries and in part undoubtedly to the gaining favor of cement and concrete for certain construction purposes. The latter has manifested itself particularly in the loss of trade among the bluestone quarries which supply flagstone to New York and other eastern cities. This branch of the industry has shown a decline of over 50 per cent in the last four years.

The total value of the stone quarried in 1911 was $5,455,312, as compared with a reported value of $6,193,252 in 1910. The decrease thus indicated was $737,940 or 12 per cent. The output for 1909 had a value of $7,061,580, showing that a falling off of about 30 per cent has taken place in the interval. It should be noted that the above figures do not include slate, millstones, or limestone used for cement manufacture, which are reported separately.

The output of granite participated in the decline to a marked extent, falling from a value of $244,763 in 1910 to $148,633 last year. The quarries in the Adirondacks and on the St Lawrence river reported a reduced business, and those in southeastern New York were less active than heretofore. New developments in the syenite and anorthosite areas of Clinton and Essex counties have been under way but have not yet reached the stage that enables large shipments to be made.

No great change occurred in the limestone production; the quarries of that material reported a value of $3,174,161 against $3,245,807 in the preceding year. The wide use of limestone for concrete and road work has steadied the market, though conditions in some branches were rather unfavorable.

The value of the marble that was quarried last year amounted to $278,041 against $341,880 in 1910. The main decrease was in building marble from the Dutchess county quarries. The output of monumental marble from Gouverneur was fairly well maintained. The sandstone quarries registered a large falling off in production, returning a total value of only $955,063, less than reported in any recent year. The output in 1910 had a value of $1,451,796. Most of the decrease came from the bluestone quarries.

The trap quarries in the Palisades section produced about as usual, though the reduction or extinction of the present industry is in prospect for the near future owing to the inclusion of the quarry properties in the new Palisades park. One of the quarries terminated its activity during the past season. The production of trap in the State amounted in value to $899,414, against $909,006 in the preceding year, practically all of it in the form of crushed stone.

Production of stone in 1909

VARIETY	BUILDING STONE	MONUMENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite..........	$35 019	$33 818	$1 352	$182 029	$227 737	$479 955
Limestone........	217 109	....	15 363	1 744 314	1 323 597	3 300 383
Marble...........	262 934	104 495	25	6 403	6 159	380 016
Sandstone........	358 589	....	783 880	220 200	477 129	1 839 798
Trap.............	....	....	....	1 061 428	....	1 061 428
Total........	$873 651	$138 313	$800 620	$3 214 374	$2 034 622	$7 061 580

Production of stone in 1910

VARIETY	BUILDING STONE	MONUMENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite..........	$40 911	$12 989	*a*	$91 988	$98 875	$244 763
Limestone........	99 049	....	$3 888	1 815 809	1 327 061	3 245 807
Marble...........	252 965	88 684	....	....	231	341 880
Sandstone........	387 408	....	408 132	225 408	358 848	1 451 796
Trap.............	....	....	....	908 931	75	909 006
Total........	$780 333	$101 673	$484 020	$3 042 136	$1 785 090	$5 193 252

a Included under "All other."

Production of stone in 1911

VARIETY	BUILDING STONE	MONUMENTAL	CURBING AND FLAGGING	CRUSHED STONE	ALL OTHER	TOTAL VALUE
Granite..........	$30 684	$11 353	*a*	$72 401	$34 195	$148 633
Limestone........	112 082	....	$11 989	1 936 292	1 113 798	3 174 161
Marble...........	171 748	79 115	....	....	27 178	278 041
Sandstone........	317 571	....	431 047	23 883	182 562	955 063
Trap.............	....	....	....	896 164	3 250	899 414
Total........	$632 085	$90 468	$443 036	$2 928 740	$1 360 983	$5 455 312

a Included under "All other."

GRANITE

In the strict sense granite is an entirely crystalline rock made up of feldspar and quartz, usually with subordinate amounts of one or more minerals of the mica, hornblende and pyroxene groups. Among quarrymen and builders, however, the name granite is given to various other massive rocks that consist chiefly of silicate minerals, such as the heavier and darker colored types included under diorites, norites and gabbros, also syenite which resembles granite but lacks quartz, as well as metamorphic varieties included under gneisses and schists. This usage will be followed for the purposes of the present report, except that the basic dike rocks which are chiefly exploited for crushed stone are treated under the head of trap.

The granite trade for the past few years has not been in a flourishing condition. The production in 1911 showed a considerable decline compared with the reported total for the preceding year which was well below the output in 1909. The decrease has been largely in the less valuable grades of crushed stone and paving blocks, but on the other hand the trade in building and monumental granite has failed to reveal any decided upward trend.

The total production of granite in 1911 had a value of $148,633 against $244,763 in 1910, and $479,955 in 1909. Building stone, rough and dressed, accounted for $30,684 in the total, as compared with $40,911 in the preceding year and $35,019 in 1909. The output of monumental stone was valued at $11,353 against $12,989 in 1910; crushed stone at $72,401 against $91,988; rubble and riprap at $28,162 against $20,272; and all other kinds at $6033 against $78,603 in 1910.

Production of granite

	1909	1910	1911
Building stone	$35 019	$40 911	$30 684
Monumental	33 818	12 989	11 353
Crushed stone	182 029	91 988	72 401
Rubble, riprap	12 737	20 272	28 162
Other kinds *a*	216 352	78 603	6 033
Total	$479 955	$244 763	$148 633

a Includes curbing, paving blocks and minor uses.

NOTES ON THE GRANITE QUARRIES OF NEW YORK

The following notes relating to the granite industry are based on the results of a field investigation carried out during the summer of 1911, as an initial step toward the preparation of a comprehensive account of the quarry resources in the State. Assistance in the field work has been given by R. W. Jones of the State Museum staff.

No complete report on the quarry materials of the State has been issued since the publication of Smock's *Building Stone in New York,* which appeared in 1890 as Bulletin 10 of the State Museum. This work presents a brief but serviceable description of the quarries in existence at the time, as well as chapters on the use of stone in cities, physical tests, and the durability and causes of decay of building materials; it is still a valuable reference work though, of course, scarcely representative of present conditions in the industry. A short paper on the granite quarries in southeastern New York is included in the report of the State Geologist for 1900. This paper, prepared by Edwin C. Eckel, was intended to be only preliminary to a more detailed treatment of the granite and marble industries of the whole State. It affords information in regard to many quarry localities not mentioned in Smock's report, and gives a short description of the geological structure of the region as a basis for the classification of the building stones.

Adirondack region. The great expanse of crystalline rocks included in the Adirondacks and the bordering area affords a variety of quarry materials. The commoner types which are useful for building or monumental stone comprise granites proper, syenites and anorthosite. These are found in both massive and gneissoid development. Gabbros and various dike rocks of which diabase is the most abundant representative occur locally and have limited application for purposes of road improvement and engineering construction.

The quarry industry of this region has made slow progress. Until recent years its development was greatly retarded by lack of adequate transportation facilities and the high costs of shipment to the important markets. Though of less consequence than formerly, the factor of transportation is still of critical importance in some sections, particularly as competition has became very keen with the advantage naturally inclining toward the long-established enterprises of other districts which have attained a certain prestige in the trade. At present the only promising fields for industry are to be found in the marketing of special grades of stone which command attention through their exceptional attractiveness or their adaptability to certain uses.

Among the better known quarry materials for building and monumental purposes are the red granites on the northwestern side of the Adirondacks, the green syenite which is found in various sections as larger or smaller intrusive masses, and the light gray anorthosite which constitutes the great central core of the mountains and is exposed in outliers to the north and east of the main area. Some of the more accessible and important localities for these materials will be described.

St Lawrence river granites. The red granite of Grindstone, Picton and Wellesley islands in the St Lawrence river is one of the characteristic products of the region, widely known as an excellent building and monumental stone. It ranks with the best native granites of its kind. The several exposures on the group of islands between Clayton and Alexandria Bay belong to a single large but irregular mass which in the recently issued geological report covering that section is described and mapped as the Picton granite. In general it is a bright red coarsely textured granite in which the predominant ingredient is feldspar in large red individuals, with quartz and biotite. Most of the product in earlier years came from Grindstone island which furnished large quantities of structural and monumental material to the cities on the St Lawrence and the Great Lakes. Paving blocks were also made in quantity. These quarries are now idle or worked only in a small way. They are situated mainly along the western shore of the island. The quarry of the old Chicago Granite Co., now owned by H. B. Kelly of Clayton, has been more active than the others of late and has furnished stone for many of the structures along the river. The Forsyth quarry in the same vicinity supplied the large columns erected in the Senate chamber of the Albany Capitol. Though of coarse texture the stone has excellent polishing qualities.

The principal quarry operations in the area are now carried on by the Picton Island Red Granite Co., whose property is situated on the northern end of Picton island, between the larger Grindstone and Wellesley islands. The company has three quarries opened in the natural ledges which rise directly from the shore line to a height of 50 or 75 feet and which afford great advantages for economic work. The output as it comes from the quarries or from the cutting yards can be loaded directly on boats for river and lake shipment. Rail shipments are made from Clayton where the company has its own docks and yards. The granite is of finer texture than that from Grindstone island; two varieties are obtained, one with a medium grain and red body flecked with black and the other of finer grain with a uniform pink tint. The latter finds special favor for monumental work on account of its capacity for taking fine tool work and the strong contrast of the hammered and rubbed surfaces. The medium grained granite is very suitable for structural material, its rock and hammered surfaces having a pleasing warm tone, of lighter shade than the polished material. Some of the structures for which this stone has been used include the new part of the American Museum of Natural History in New York, the National Bank in Clayton and the Maryland Museum Building (polished columns) in Baltimore.

An exposure of granite in the vicinity of Alexandria Bay has been of some importance for the production of paving blocks and rough stone. It is a finely textured stone which shows the effects of regional compression, and belongs really to the gneissic types that are so widespread in the western Adirondacks. The principal quarry is a little south of Alexandria Bay and is opened in a knob that rises 100 feet or more above the river. It is owned by J. Leopold & Company of New York. The granite is rather variable in color which is a drawback to its general use for cut stone though well adapted for other purposes. It belongs to the biotite-muscovite class and is mainly composed of alkali-feldspar and quartz.

Granite in southern St Lawrence county. One of the largest areas of massive granite in the Adirondacks is found in the towns of Fine and Pitcairn, St Lawrence county, probably extending also into the adjacent section of Lewis county. The area has not been delimited or mapped as yet, and has never attracted attention apparently for quarry development though traversed by the Carthage & Adirondack Railroad which makes it accessible to the markets of northern and central New York. The granite appears in practically continuous outcrop for a distance of 8 miles along the railroad, in the stretch between Harrisville and Benson Mines. The more available section lies between milestones 56 and 64 of the railroad line, or 25 miles east of Carthage and a little over 40 miles from Watertown. The granite for the most part shows a coarse massive texture, but medium grained types appear near the borders where also it becomes more or less gneissoid. Compared with the Thousand Islands granite it has a lighter color, being light red to pink, with often a mottled pink and white appearance from the varicolored feldspar. There are abundant quarry sites along the railroad, as many of the ridges within the central part of the area afford natural exposures several hundred feet high. The results of field and laboratory examination show the stone to be sound and free of injurious ingredients and practically fresh at the surface. The following analysis of a sample of the granite is by R. W. Jones:

SiO_2	72.69
Al_2O_3	14.11
Fe_2O_3	.26
FeO	2.89
MgO	.28
CaO	.64
Na_2O	2.37
K_2O	5.16
H_2O+	.24
H_2O-	.02
	98.66

Sulfur was tested for but not found. The minor constituents including manganese, phosphorus and zirconium, the presence of which was indicated by microscopic analysis, were not estimated.

The granite is bordered on the west by a great intrusion of syenite that is estimated by C. H. Smyth, jr, to cover not less than 75 square miles. The syenite is a grayish green to dark green or nearly black rock composed largely of feldspar but containing considerable amounts of pyroxene, amphibole and magnetite. In its original or unaltered phase it has a coarse massive texture, but the general appearance is that of a granulated and more or less recrystallized rock, showing much more evidence of pressure metamorphism than the granite. The syenite is not adapted for building stone on account of its somber color. For engineering purposes it should prove very serviceable.

Quarries in Clinton and Essex counties. In the eastern Adirondacks the available quarry materials suitable for architectural and monumental work consist of granite, syenite and anorthosite. These formations are of widespread occurrence but in comparatively few places do they possess the qualities requisite for cut stone as they have been largely metamorphosed into gneisses and schists. The unreduced or slightly modified residuals of the igneous intrusions which are found here and there along the borders afford the basis for quarry operations.

The vicinity of Ausable Forks presents many advantages for quarrying in connection with both anorthosite and syenite. For several years past a considerable quantity of monumental stone has been shipped from this section, and recently additional developments with a view to the extraction of all classes of rough and cut stone have been planned.

The Adirondack Granite Co., formed in 1910 as a consolidation of the properties formerly owned by Moore Brothers and the Ausable Granite Co., controls a large acreage of the syenite and anorthosite in that vicinity which as yet is only partly developed. The syenite quarries lie on both sides of the Ausable river, the more important property covering the ridge which lies north of the river and just east of the village. This is an excellent situation, both for economic extraction and shipment. The syenite is of medium grain and has a bright green color on polished surfaces. It is composed mainly of alkali-feldspar and magnetite. It is particularly adapted for monumental work, taking a lustrous polish and showing the finest tracery in strong relief. It is sold under the name of " Adirondack green granite." The company has a second quarry on the west side of Ragged mountain, south of the river, where the rock is of finer grain and darker color. This is marketed as " Killarney green granite." The anorthosite properties are situated south of the village on the ridge along the east branch of the Ausable. This has been opened only in one place, the Wienholz quarry, from which some building stone has been shipped. The anorthosite belongs to the border phase, having a fine ground mass of crushed feldspar which lends a medium gray tone to the rock as seen in large samples, whereas the characteristic Adirondack type has a very coarse texture and dark gray or green color. The light body is set off by inclusions of black pyroxene and hornblende, with an occasional fragment of dark uncrushed feldspar showing the iridescent play of colors peculiar to labradorite. The color effect of the rough and dressed surfaces is about that of a medium gray granite, for which it is an all-round substitute. Owing to its simple mineral character the anorthosite has superior fire-resisting qualities, an important consideration for some purposes. It is no doubt a strong and durable stone.

The syenite quarries owned by F. G. Carnes of West Chazy are situated just south of Ausable Forks. The Keystone lies near the base of Ragged mountain and yields a green syenite of lighter shade than that from the quarries at a higher elevation. The Emerald quarry is situated on the westward continuation of the exposure across the river. The stone from this locality is a medium dark green and rather fine in texture. Both afford excellent monumental material.

Another syenite quarry, known as the Clements quarry, is situated on the side of Ragged mountain overlooking Ausable Forks. It has shipped some monumental stock.

There are a number of anorthosite exposures in the vicinity of Keeseville, from which building material has been taken for local structures and also for shipment in years past. The stone passed in the trade as Ausable granite. The Prospect Hill quarries, just south of Keeseville, are described in Smock's reports as having been operated between the years 1888 and 1890.

Southeastern New York. Massive igneous rocks play a subordinate part in the structure of the Highlands region. Local intrusions of granite, diorite and syenite in the form of dikes, sills and bosses occur, however, in various sections, and afford a fairly varied assortment of quarry materials. Among the more extensive bodies which have gained some prominence as sources of constructional stone may be mentioned the Peekskill or Lake Mohegan granite, the granites near New Rochelle and Garrisons, and the Pine Island bosses in Orange county. An area of somewhat gneissoid diorite, called the Harrison diorite, is found in eastern Westchester county, as an offshoot from the large intrusions of the same rock in Connecticut.

The very basic intrusives are represented by the Cortlandt series of gabbros, having a large boss just south of Peekskill, but showing such variability of composition and appearance as to be of little value for quarry purposes. In this class also belong the serpentines of Westchester and Richmond counties. The great sill of diabase which forms the lines of vertical cliffs known as the Palisades extending along the west side of the Hudson river south from the Highlands has been a prolific source of material for crushed stone of the best quality.

The gneisses which are the most important element in the geology of this section have a composite character, including both igneous and sedimentary derivatives. Some types in the northern and central Highlands appear to be only slightly modified granites, as exemplified by the exposures on Storm King, Crow's Nest and Breakneck mountains at the portal of the Hudson gorge. They have been employed for dimension stone, but mainly for rough work, concrete and road material. Much of the gneiss in the central Highlands is of so variable a nature through injection of igneous material and inclusions of different character as to admit of no extensive application.

In Westchester county the Yonkers gneiss is of considerable importance for local construction purposes. It is a fairly uniform, though distinctly foliated, biotite gneiss of blue or reddish color.

Another member of the gneiss series, the Fordham, occupies extensive belts in the county; it is a banded biotite gneiss and finds limited use for local building and rough work.

Peekskill granite. This is one of the best known constructional granites of the region. It is exposed in two areas about a mile south of Lake Mohegan and five miles east of Peekskill, the two outcrops probably belonging to the same intrusion. The more northerly outcrop is included in the quarry lands of the Mohegan Lake Granite Co.; the other to the south and nearer Peekskill has been worked as the Millstone Hill quarries.

The former quarries were opened in 1892 to supply stone for local engineering works and have since furnished large quantities of building stone, chiefly to New York City and for such notable structures as the new Episcopal Cathedral. The granite is a biotite-muscovite variety, of medium grain, massive and free of knots and streaks. It occurs in two contrasting colors — yellow and light gray. The rare and very attractive yellow granite forms the surficial outcropping part of the mass, changing to the normal gray at about 50 feet depth. The peculiar coloration is the effect of limonite stain introduced by seepage of ground water, and is not brought about by weathering of the stone itself. The quarries are large and well equipped. There is also a crushing plant for employment of the waste material.

The Millstone Hill quarries opened in a north-facing ridge, across the valley from the above mentioned property, are owned by Rudiger Brothers, but have been worked until recently by the contractors of the Croton dam. Besides all the stone used in that structure they have supplied some building material for use in Peekskill and other places. The excavations cover an area of about 500 feet long by 200 feet wide and extend to a depth of 40 feet. The granite is of medium grain, very light gray, with more muscovite than that from the Mohegan Lake quarries. There has been little infiltration of limonite, and the gray color persists practically to the surface. The granite is well adapted for building and all general purposes.

Quarries near Garrison. About five miles north of Peekskill and half that distance south of Garrison is an isolated intrusion of granite which has supplied a considerable quantity of building stone. The quarries were worked by the King Granite Co. and later by Doern & Sons, but have not been active since 1906. They will not be reopened, though there is some prospect of starting work at a new place, on lands owned by Raymond Moore, just south of the King quarries. The granite is of light gray color, medium to fine in grain, and belongs to the biotite variety. A characteristic component is red garnet in small but plainly visible grains or crystals disseminated through the body of the rock. Like the Peekskill granite it belongs rather to the basic class allied to the diorites and may be an offshoot of the Cortlandt intrusion. The granite has been employed mainly in buildings in the towns along the river. The guard house at West Point is a specimen structure.

Yonkers gneiss. There are only a few quarries now active in the Yonkers gneiss, though a considerable number are listed by Eckel[1] as having been worked at the time of his report and the few preceding years. The principal area of the gneiss is a belt that extends from near Van Cortlandt Park to Scarsdale in southern Westchester county and that forms the ridge west of the Bronx river. It also occurs in a considerable area between White Plains and Kensico to the east of the Harlem railroad. There are different color varieties of the gneiss and Eckel states that the red varieties are more open to decay than the blue, though for what reason he does not explain.

One of the large quarries in the Yonkers gneiss is that of Hackett Brothers situated at the junction of Midland and Central avenues, Dunwoodie. It is opened for a distance of 800 feet and has a working face 40 feet high. The stone in the quarry has a bluish appearance, but the hand specimens have a decided pink tinge from the prevailing color of the feldspar. The grain is fine and the arrangement somewhat foliated owing to the regular distribution of the biotite in parallel bands. The jointing is not so close as to preclude the extraction of large-sized blocks. Most of the output is dimension stock. Good examples of the stone from the quarries are found in many of the buildings in Yonkers, including St John's and St Joseph's hospitals and several of the public schools.

In the same vicinity is the quarry worked by John Russo. It produces building stone in small quantity for local sale. In character and appearance the gneiss is similar to that obtained at the Hackett quarry, but the jointing is more closely spaced, permitting the extraction of few large blocks.

The quarry of Louis Perri lies a little east of the Hackett quarry.

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[1] The Quarry Industry in Southeastern New York. Ann. Report State Geologist 20, 1902. Also published separately.

The opening is about 100 feet square with a face of 30 feet. Most of the output, which is small, is cut and dressed on the property.

The Flannery quarry, also at Dunwoodie, is an occasional producer of building material. The quarries formerly worked at White Plains, Hartsdale, Tuckahoe, Hastings and Tarrytown have been closed down and the lands converted to other uses.

Fordham gneiss. The Fordham is a light gray banded gneiss, made up of feldspar, quartz and biotite. It is regarded as a metamorphosed sediment, though in places it has been so injected with granite that the igneous material predominates. The gneiss varies much from place to place and even in the limits of a single quarry. Its use, consequently, is mainly for rough stone in foundation work.

The quarry owned by Patrick Reilly in the village of Dublin, Westchester county, has been one of the few producing building material. It has been worked more or less actively for the past 35 years, and recently has been under lease to Thomas Murphy of Irvington. It is opened for a width of 200 feet, with a face from 30 to 50 feet high. The rock is hard, much contorted gneiss, seamed with granite and pegmatite. It has been used in several residences and for some local public buildings.

The Lefurgis quarry, near Unionville, consists of an opening about 100 feet wide with a face of 30 feet. It affords building and rough stone and is to be equipped with a crushing plant. It is operated under lease by William Nichols, jr.

A quarry at Glenville is worked by Duell & Holloway for crushed stone. The old quarries at Uniontown, Bryn Mawr, Lowerre and Fordham are no longer active.

Storm King granite gneiss. The granite exposed on Storm King, Breakneck, Crow's Nest and other prominences in the northern Highlands represents the most considerable body of that rock in massive or slightly modified condition existing anywhere in the southeastern section. It belongs doubtless to the early Precambric series, older than the small granite intrusions around Peekskill. Its appearance in places is that of a medium to coarse massive granite, but more often it shows a distinctly gneissoid arrangement of the minerals and more or less crushing effects. It is a strong and very durable stone that has been used mainly for rough construction and crushing purposes. Its color ranges from medium to dark according to the relative proportion of hornblende that is admixed with feldspar and quartz, the general tone being reddish or greenish. There are quarries and crushing plants at the base of

Storm King mountain below Cornwall and also directly opposite on the east bank of the river, on the side of Breakneck ridge. The latter, known as the Bailey quarries, have supplied considerable building stone.

Granite near Warwick. Several granite intrusions occur in the southeastern part of Orange county, near the New Jersey state line. Two of them constitute bosses that rise into the conspicuous twin peaks Adam and Eve on the edge of the Wallkill "Drowned Lands." Both are made up of coarse hornblende granite, somewhat gneissoid in places and showing pegmatitic and aplitic variations. Mt Eve, the larger, occupies an area about two miles long and a mile wide. Mt Adam is a nearly round mass one-half mile in diameter. There are small knobs of the same granite near Big Island, northeast of Mt Eve, and also in the section southwest along the general axis of the intrusion. Another large intrusion is found on Pochuck mountain, a broad ridge which mainly lies in New Jersey. The northern end that comes within New York State consists of coarse quite massive hornblende granite bordered on the west by biotite gneiss. Quarries have been opened on the northern slope of Mt Adam and the western slope of Mt Eve. The Mt Adam Granite Co. worked at the former locality for several years, beginning about 1889. The quarry opening has a length of 250 feet and a face from 20 to 30 feet high. The granite is mainly a coarse, medium gray, hornblende variety, but with this is associated a finer grained aplitic granite that forms bands and inclusions in such amount as to prevent the extraction of uniform material.

The Mt Eve quarries were opened about 1890 by the Empire Granite Co. which was also engaged in operating the Pochuck mountain quarries. They are situated a little way up the western slope of Mt Eve in the notch. The granite is less broken and more uniform in quality than on Mt Adam. It was employed quite extensively for dimension stone which was sold in Orange, N. J., and other places. The quarries lie one and a half miles from the railroad.

The Pochuck mountain quarries were worked up to about five years ago and have produced mainly building stone and paving blocks. They are opened for a width of 200 feet along the mountain showing a face from 30 to 40 feet high. The granite is slightly foliated in places, but has an attractive appearance, with a pink body mottled by gray and black. Its use as a building stone is exemplified in the post office at Paterson, N. J.

LIMESTONE

The stone classified under this heading consists for the most part of the common grades of limestone and dolomite such as are characterized by a compact granular or finely crystalline texture and are lacking in ornamental qualities.

A smaller part is represented by crystalline limestone and by the waste products of marble quarrying which is sometimes employed for crushed stone, lime-making or flux. Limestone used for the manufacture of portland and natural cement is, however, excluded from the tabulations so as to avoid any duplications of the statistics.

Limestones have a wide distribution in the State, the only region which is not well supplied with this stone being the southern part where the prevailing formations are sandstones of Devonic age. The noncrystalline varieties occur in regular stratified order in the Cambric, Lower Siluric, Upper Siluric and Devonic systems. In most sections they occupy considerable belts and have been little disturbed from their original horizontal position. On the borders of the Adirondacks and in the metamorphosed Hudson river region, however, they have been more or less broken up by faulting and erosion and in places have a very patchy distribution.

The Cambric limestones are found in isolated areas on the east, south and west sides of the Adirondacks. They are usually impure, representing a transition phase between the Potsdam sandstones below and the high calcium limestones above. The lower beds of the Beekmantown formation as originally defined are now known to belong to the Cambric system. The Little Falls dolomite is perhaps the most prominent member of the Cambric limestones and is extensively developed in the Mohawk valley with quarries at Little Falls, Mayfield, Amsterdam and other places. It is a rather heavily bedded stone of grayish color, suitable more especially for building purposes. In Saratoga county the Hoyt limestone is in part the equivalent of the Little Falls dolomite; it has been quarried for building stone just west of Saratoga Springs. On the west side of the Adirondacks the Theresa limestone is described by Cushing as a sandy dolomite which may in part belong to the Cambric system. It is comparatively thin and has no importance for quarry purposes.

The Beekmantown limestone which is now taken as including the middle and upper beds of that series as earlier defined is mostly restricted to the Champlain valley. It occurs on the New York shore in rather small areas, usually down-faulted blocks, that are the remnants of a once continuous belt. It is also represented doubtless in the basal portion of the limestone area that extends across Washington and Warren counties. The only place where it has been extensively quarried is at Port Henry where the purer layers have been worked for flux. In the Lake Champlain region it is a bluish or grayish magnesian limestone occurring in layers from a few inches to several feet thick.

The Chazy limestone is found in the same region as the Beekmantown in discontinuous areas along the eastern Adirondacks from Saratoga county north to the Canadian boundary. It attains its maximum thickness in eastern and northeastern Clinton county, and has been quarried around Plattsburg, Chazy and on Valcour island. The Chazy is the earliest representative of the Paleozoic formations characterized by a fairly uniform high calcium content; analyses commonly show 95 per cent or more of calcium carbonate. It has a grayish color and finely crystalline texture. The fossiliferous beds afford attractive polished material which is sold as "Lepanto" marble. It is used also for lime and furnace flux. There are old quarries on Willsboro point, Essex county. On the west side of the Adirondacks the Pamelia limestone described in the areal reports of that section belongs to the Chazy series. It covers a considerable area in Jefferson county between Leraysville and Clayton, and has been quite extensively quarried for building stone and lime, though of subordinate importance to the Trenton limestones of that section.

In the Mohawkian or Trenton group are included the Lowville (Birdseye), Black River and Trenton limestones which have a wide distribution and collectively rank among the very important quarry materials of the State. They are represented in the Champlain valley, but are specially prominent on the Vermont side; from the latter area a belt extends southwest across northern Washington county to Glens Falls in Warren county and is continued into Saratoga county. Another belt begins in the Mohawk valley near Little Falls and extends northwesterly with gradually increasing width across Oneida, Lewis and Jefferson counties to the St Lawrence river. There are isolated areas of Trenton limestones in the Hudson valley south of Albany. The limestones vary in composition and physical character according to locality and geologic position. They are often highly fossiliferous. In the northern section they are mostly gray to nearly black in color, contain little magnesia and run as high as 97 or 98 per cent calcium carbonate.

The lower part of the group is heavy bedded and well adapted for building stone; the upper beds commonly contain more or less shale. They are used for various purposes including building and ornamental stone, crushed stone, lime, portland cement and flux. In the Champlain valley quarries are found near Plattsburg, Larabees Point and Crown Point; in Washington county at Glens Falls where there are extensive quarries that supply material for building purposes, portland cement and lime. The well-known black marble from Glens Falls is taken from the Trenton. Numerous quarries have been opened in Herkimer, Oneida, Lewis and Jefferson counties. The output of the last named county is specially important, including limestone for building and road construction, and lime for manufacture of calcium carbide. The principal quarries in Jefferson county are at Chaumont.

The next assemblage of limestones in the order of stratigraphic occurrence includes the Clinton, Lockport and Guelph members of the Niagaran group. The Clinton limestone has a variable importance in the belt of Clinton strata that extends from Otsego county a little south of the Mohawk river across the central and western parts of the State on the line of Oneida lake and Rochester to the Niagara river. East of Rochester the limestone is relatively thin, usually shaly and split up into several layers, but on the west end in Niagara county it becomes the predominant member and has a more uniform character. Large quarries have been opened recently at Pekin, Niagara county, for the supply of flux to the blast furnaces of the Lackawanna Steel Co. at Buffalo. The upper beds of bluish gray fossiliferous limestone from 10 to 12 feet thick are the purest and analyze from 90 to 95 per cent calcium carbonate. The Lockport is a magnesian limestone, in places a typical dolomite, and is rather silicious in the lower part. It outcrops in a continuous belt, several miles wide, from Niagara Falls east to Onondaga county and then with diminishing width across Madison county. The upper layers are quite heavy and yield material suitable for building purposes, road metal and lime. There are quarries around Niagara Falls, Lockport and Rochester. It is worked to some extent in Wayne, Onondaga and Madison counties. The Guelph, also a dolomite, occupies a limited area in Monroe and Orleans counties and is worked near Rochester.

The Cayugan group includes among its members the Cobleskill, Rondout and Manlius limestones, which are economically important. They have furnished large quantities of material for the manufacture of natural cement, being the source of the cement rock in the

Rosendale district and in Schoharie and Onondaga counties. The cement rock of Erie county is found in the Salina formation. The purer layers are employed in Onondaga county for lime-making. The Manlius limestone is used for portland cement in the eastern part of the State.

At the base of the Devonic system appears the Helderbergian group which is very prominent for its calcareous strata. Limestones of this age are strongly developed along the Hudson river in Albany, Columbia, Greene and Ulster counties. The Coeymans or lower Pentamerus and the Becraft or upper Pentamerus limestones afford material for building, road metal, lime and portland cement. The limestone for the portland cement works at Hudson and Greenport is obtained from Becraft mountain, an isolated area of limestones belonging to the Manlius, Helderbergian and Onondaga formations. The works at Howes Cave use both the Manilus and Coeymans limestones. Extensive quarries are located also at Catskill, Rondout and South Bethlehem.

The Onondaga limestone, separated from the preceding by the Oriskany sandstone, has a very wide distribution, outcropping quite continuously from Buffalo, Erie county, eastward to Oneida county and then southeasterly into Albany county, where the belt curves to the south and continues through Greene, Ulster and Orange counties to the Delaware river. It is in most places a bluish gray massive limestone with layers and disseminated nodules of chert. The chert is usually more abundant in the upper beds. The limestone finds use as building stone and the less silicious material, also, for lime-making. Quarries have been opened at Kingston, Split Rock (near Syracuse), Auburn, Waterloo, Seneca Falls, Leroy, Buffalo and other places.

The Tully is the uppermost of the important limestone formations and likewise the most southerly one represented in the central part of the State. Its line of outcrop extends from Ontario to Madison county, intersecting most of the Finger Lakes. Its thickness is not over 10 feet, and on that account can not be worked to advantage except under most favorable conditions of exposure. For building stone it is quarried only locally and to a very limited extent. It finds its principal use in portland cement manufacture, being employed for that purpose by the Cayuga Lake Cement Co. in its works at Portland Point, Tompkins county.

Marl is a useful substitute for the hard limestones for some purposes and is quite extensively developed in the central and western parts of the State. It is found particularly in swampy tracts and old lake basins associated with clay and peat. In the Cowaselon swamp near Canastota the marl underlies several thousand acres and is said to be 30 feet thick. The Montezuma marshes in Cayuga and Seneca counties contain a large deposit which at Montezuma is 14 feet thick. In Steuben county the marls at Arkport and Dansville have been employed for lime-making. Until recently marls have been used quite extensively for portland cement and plants were operated at one time in the marl beds near Warners and Jordan, Onondaga county; at Montezuma, Cayuga county; Wayland, Steuben county; and Caledonia, Livingston county. Their principal use at present is for agricultural and chemical purposes.

Production of limestone. The limestone quarries rank first in importance among the stone industries. The product for 1911 was valued at $3,174,161 and was distributed among 31 counties. The returns showed a slight decrease as compared with the output in 1910, which was valued at $3,245,807, and was also below that reported for 1909.

Production of limestone

MATERIAL	1909	1910	1911
Crushed stone	$1 744 314	$1 815 809	$1 936 292
Lime made	452 874	365 839	400 396
Building stone	217 109	99 049	112 082
Furnace flux	434 311	538 491	454 800
Rubble, riprap	82 748	30 819	20 328
Flagging, curbing	15 363	3 888	11 989
Miscellaneous	353 664	391 912	238 274
Total	$3 300 383	$3 245 807	$3 174 161

Erie county had the largest output of any county; its products are chiefly building stone, crushed stone and furnace flux. The total value of the limestone quarried in the county last year was $843,615.

Onondaga county ranks second in the list, but its importance is chiefly due to the operations of the Solvay Process Co. which uses the limestone in alkali manufacture. The company has recently opened new quarries at Jamesville, with equipment for the production of sufficient limestone to meet its requirements. The old quarries at Split Rock have been abandoned.

The other counties reporting a value of over $100,000 in 1911 were Dutchess, Rockland, Genesee, Warren, Ulster, Niagara, and Albany, ranking in the order given.

The distribution of the limestone production by counties and also according to uses is shown in the accompanying tables.

Crushed stone. Limestone finds its principal application as crushed stone in which form it is extensively employed for road metal, concrete and railroad ballast. There are large quarries in Erie, Genesee, Dutchess and Rockland counties besides a great number of smaller ones elsewhere, that are equipped with crushing plants. The canal and highway improvements which have been in progress recently have created a large market for the material, and the production has shown a steady increase. The waste or fine dust that results from crushing is finding use as a fertilizer for soils deficient in lime.

The value of the crushed limestone for 1911 was reported at $1,936,292, as compared with $1,815,809 for the preceding year. The total quantity represented was 3,116,958 cubic yards against 2,800,000 cubic yards in 1910. Erie county alone contributed an output valued at $489,881. The other counties reporting a value of over $100,000 last year were Dutchess, Rockland, Onondaga, Genesee and Albany.

Lime. The total value of the lime made in 1911 was $400,396. This represented a considerable advance from the total of $365,839 reported in 1910, but fell short of the record for 1909. The lime made by the Solvay Process Co. and the Union Carbide Co. has not been included in the totals given, but classed under "Other uses." The leading counties in the manufacture of lime for the trade were Warren, Clinton and Jefferson.

Building stone. The limestones found in the State have only a limited sale for building purposes and few quarries supply more than a local demand so that their output fluctuates greatly from year to year. The restricted market seems to be largely due to the fact that the limestones are prevailingly of grayish color in medium to dark tints, whereas the present demand is for white or very light gray stone such as the Bedford limestone. The extending use of concrete has also been a factor in the recent decline of the cut stone trade, though it has increased the sale of crushed stone.

The returns for 1911 showed a total product of building stone valued at $112,082, as compared with a value of $99,049 in the preceding year. The small gain indicated by these totals did not suffice to counterbalance the decline in the previous years; in 1908 the product of building stone reached a value of $245,655. Erie county contributed a value of $77,689 to the total last year. The industry in Schoharie and Herkimer counties, once quite important, has shrunk to small proportions.

Furnace flux. The value of the limestone used in furnaces for flux is second only to that of crushed stone. The principal quarries of this material are in the Onondaga limestone of Erie and Genesee counties and the Clinton limestone of Niagara county. They supply the iron furnaces at Buffalo and vicinity. Some flux is obtained in the Gouverneur marble region for use in the furnaces at Charlotte. The furnaces in the Lake Champlain section derive their flux from quarries in Clinton and Essex counties.

The production of flux in 1911 was valued at $454,800 representing a total of 792,248 tons. The shipments were smaller than in the preceding year, owing to the dull conditions in the iron market. Erie county contributed the largest value, $268,082, and Niagara county ranked second with $141,824.

Production of limestone by counties in 1910

COUNTY	CRUSHED STONE	LIME MADE	FURNACE FLUX	BUILDING STONE	OTHER USES	TOTAL
Albany	$125 450	$4 500	....	....	....	$129 950
Cayuga	39 019	....	....	$7 690	....	46 709
Clinton	13 549	48 823	$12 364	4 160	....	78 896
Erie	476 490	152	322 067	53 881	$13 745	866 335
Genesee	118 797	5 000	90 132	480	200	214 609
Greene	8 225	....	....	....	....	8 225
Herkimer	8 520	3 114	....	....	....	10 434
Jefferson	1 693	*a* 55 837	....	200	168 265	225 995
Lewis	1 195	3 200	....	520	726	5 641
Madison	52 028	....	2 625	800	....	55 453
Monroe	17 423	29 520	....	2 589	1 719	51 251
Montgomery	29 810	....	....	8 622	2 125	40 557
Niagara	5 000	4 000	76 695	3 197	406	89 298
Onondaga	150 640	*a* 1 620	....	12 092	233 228	397 580
Rensselaer	15 000	....	....	100	70	15 170
St Lawrence	870	7 240	27 008	362	1 116	36 596
Saratoga	15 114	....	....	7	....	15 121
Schoharie	12 441	128	....	1 567	624	14 760
Seneca	1 625	192	192	1 192	75	3 276
Ulster	20 654	11 897	....	....	....	32 551
Warren	31 378	140 576	....	1 583	....	173 537
Washington	50 000	44 200	....	....	....	94 200
Westchester	59 387	....	....	....	3 802	63 189
Other counties *b*	561 501	5 840	7 408	7	518	575 274
Total	$1 815 809	$365 839	$538 491	$99 049	$426 619	$3 245 807

a Lime made by Solvay Process Co. and Union Carbide Co. included in "Other uses."
b Includes Columbia, Dutchess, Essex, Fulton, Oneida, Ontario, Orange and Rockland counties.

Production of limestone by counties in 1911

COUNTY	CRUSHED STONE	LIME MADE	FURNACE FLUX	BUILDING STONE	OTHER USES	TOTAL
Albany	$132 925	....	....	....	....	$132 925
Cayuga	28 494	....	....	$12 100	....	40 594
Clinton	12 192	$62 002	$9 511	625	$579	84 909
Erie	489 881	300	268 082	77 689	7 663	843 615
Genesee	204 896	....	....	....	....	204 896
Greene	2 625	....	2 000	....	....	4 625
Herkimer	9 283	2 603	....	....	....	11 886
Jefferson	16 749	*a* 18 625	....	....	40 220	75 594
Lewis	2 850	35 000	....	95	91	38 036
Madison	34 361	22 625	5 000	100	....	62 086
Monroe	16 133	18 780	....	3 291	994	39 198
Montgomery	39 000	....	....	5 338	11 184	55 522
Niagara	....	525	141 824	800	....	143 149
Onondaga	170 402	*a* 53	....	10 178	190 704	371 337
Rensselaer	16 556	....	100	....	1 268	17 924
St Lawrence	287	6 824	24 186	652	13	31 962
Saratoga	3 792	....	....	....	....	3 792
Schoharie	19 640	300	....	457	4 600	24 997
Seneca	5 650	22	61	487	74	6 294
Ulster	167 472	19 300	....	....	....	186 772
Warren	18 161	165 064	....	270	5 621	189 116
Washington	1 000	10 000	....	....	....	11 000
Westchester	....	21 072	253	....	4 027	25 352
Other counties *b*	543 943	17 301	3 783	....	3 553	568 580
Total	$1 936 292	$400 396	$454 800	$112 082	$270 591	$3 174 161

a Lime made by Solvay Process Co. and Union Carbide Co. included in "Other uses."
b Includes Columbia, Dutchess, Essex, Fulton, Oneida, Ontario, Orange and Rockland counties.

MARBLE

The granular crystalline limestones and dolomites classed as marble are found in the metamorphosed areas of the Adirondacks and southeastern New York. A few varieties of compact, noncrystalline limestone, such as the black limestone of the Trenton formation occurring at Glens Falls and the fossiliferous Chazy limestone along Lake Champlain, possess ornamental qualities that fit them for special uses and pass as marble in the trade.

The principal quarries of monumental marble are situated in the vicinity of Gouverneur, St Lawrence county. The typical product is a rather coarse-grained, mottled white and gray marble which takes a lustrous polish. It is graded according to color effect into "light," "medium," "dark," and "extra dark." The best quality is employed for monumental and ornamental work; building stone is of secondary importance. The quarries are operated by the

Gouverneur Marble Co., St Lawrence Marble Quarries, J. C. Callahan & Sons, and the Northern New York Marble Co.

The belt of metamorphosed limestones which extends from Columbia county through Dutchess and Westchester to Manhattan island contains in places a good grade of white and gray marble. Quarries have been worked in the past at Ossining, Dobbs Ferry, White Plains, Pleasantville, Tuckahoe, Greenport, and other places. Tuckahoe has been a notable locality for white marble used in the buildings of New York City. At present the only active quarries worked for building stone are at South Dover. The South Dover Marble Co. has been the chief producer of late years and has supplied material for many of the large structures in New York, Washington and other cities. The Dover White Marble Co. has recently worked quarries in the same vicinity. The stone from this locality possesses uniformity of grain and color and is undoubtedly one of the best white marbles in this county.

A mottled pink and gray marble suitable for interior decorations is obtained from the Chazy formation at Plattsburg. The quarries recently operated by the Rutland-Florence Marble Co. have been acquired by the Vermont Marble Co.

Black marble — a fine-grained, compact, black variety of the Trenton limestone — is quarried for ornamental purposes at Glens Falls by Finch, Pruyn & Co. who ship the stone mainly in the rough state.

The production of marble in the State last year was valued at $278,041, an amount considerably below that reported in any other recent year. The value of the output in 1910 was $341,880. In 1908 it was $692,851 or more than double the output last year. The falling off, as shown in the accompanying table, has been mainly in the marble used for building purposes.

Production of marble

VARIETY	1909	1910	1911
Building marble	$262 934	$252 965	$171 748
Monumental	104 495	88 684	79 115
Other kinds	12 587	231	27 178
Total	$380 016	$341 880	$278 041

SANDSTONE

Under sandstone are included the sedimentary rocks which consist essentially of quartz grains held together by some cementing substance. Among the varieties distinguished by textural features are sandstones proper, conglomerates, grits and quartzites.

Of the sedimentary rocks which occur in the State, sandstone has the largest areal distribution, while in economic importance it ranks second only to limestone. Nearly all the recognized stratigraphic divisions above the Archean contain sandstones at one or more horizons. The kinds chiefly quarried are the Potsdam, Hudson River, Medina and the Devonic sandstones. A few quarries have been opened also in the Shawangunk conglomerate and the Clinton and Triassic sandstones.

The Potsdam of the upper Cambric is the lowest and earliest in age of the sandstones that have a fairly wide distribution and are utilized for building purposes. The most extensive outcrops are along the northern and northwestern borders of the Adirondacks in Clinton, Franklin, St Lawrence and Jefferson counties. Other exposures of smaller extent are found in the Lake Champlain valley and on the southeastern edge of the Adirondack region. These latter areas represent the remnants of a once continuous belt that has been broken up by folding, faulting and erosion. The Potsdam sandstone has in many places the character of a quartzite, consisting of quartz grains cemented by a secondary deposition of quartz, and then is a very hard, tough and durable stone. The quartzite from St Lawrence county has sustained a crushing test of more than 42,000 pounds to the square inch. The color varies from deep red to pink and white. The principal quarries are near Potsdam and Redwood, St Lawrence county, and Malone and Burke, Franklin county. Besides building stone which is the chief product, there is some flagstone sold, mainly by the quarries at Burke for shipment to Montreal.

The so-called Hudson River group is essentially a series of sandstones, shales, slates and conglomerates, ranging in age from the Trenton to the Lorraine, but which have not been sufficiently studied to permit the accurate delimitation of the various members on the map. The group is exposed in a wide belt along the Hudson from Glens Falls southward into Orange county and also in the Mohawk valley as far west as Rome. The sandstone beds are usually fine grained, of grayish color and rather thinly bedded. Over wide stretches they provide practically the only resource in constructional stone and consequently they have been quarried at a great number of places to supply the local needs for building and foundation work. Some of the stone is crushed for road metal and concrete.

The Medina sandstone is found along the southern shore of Lake Ontario from the Niagara river east to Oswego county; in central New York it is represented by a coarse conglomeratic phase called the Oneida conglomerate. As developed in the western part of the State where it is principally quarried, it is a hard fine-grained sandstone of white, pink or variegated color. The pink variety is specially quarried for building stone and has an excellent reputation. Many of the large cities of the county and most of the important towns and cities of the State contain examples of its architectural use. The large quarries are situated in Orleans county, near Albion, Holley and Medina, along the line of the Erie canal, but there are others at Lockport and Lewiston, in Niagara county and at Brockport and Rochester in Monroe county. The Medina sandstone also finds extensive application for curbing and flagging and for paving blocks. It is employed more extensively for the latter purpose than any other stone quarried in the State.

The Shawangunk conglomerate is more widely known for its use in millstones than for constructional purposes. It outcrops along Shawangunk mountain in Ulster county and southwesterly into New Jersey, with an outlier near Cornwall, Orange county. The quarries near Otisville have supplied considerable quantities of stone for abutments and rough masonry.

The Clinton sandstone is mainly developed in central New York, being absent from the Clinton belt in the western part of the State. It forms ledges of considerable extent on the south side of the Mohawk valley from Ilion to Utica and beyond. It consists of reddish brown and gray sandstones, of medium texture and hardness. The stone has been used for foundations and building in Utica and other places in the vicinity.

Of the Devonic formations which cover about one-third the whole area of the State, the Hamilton, Portage, Chemung and Catskill contain important sandstone members serviceable for quarry operations. These sandstones are popularly known as bluestone, a name first applied in Ulster county where they are distinguished by a bluish gray color. They are for the most part fine-grained, evenly bedded, bluish or gray sandstones, often showing a pronounced tendency to split along planes parallel to the bedding so as to yield smooth thin slabs. For that reason they are extensively used for flag and curbstone, and a large industry is based on the quarrying of these materials for sale in the eastern cities. Most flagstone is produced in the region along the Hudson and Delaware rivers, where there are convenient shipping facilities to New York, Philadelphia and other large cities. The Hudson river district includes Albany, Greene and Ulster counties, but the quarries are mainly situated in the area that includes southern Greene and northern Ulster, with Catskill, Saugerties and Kingston as the chief shipping points. The Delaware river district includes Sullivan, Delaware and Broome counties; the shipping stations are along the Erie and the Ontario & Western railroads. The sandstone of this section ranges from Hamilton to Catskill age. In the area to the west the quarries are confined to the Portage and Chemung groups, with the most important ones in the Portage. There are large, well-equipped quarries near Norwich, Chenango county, and Warsaw, Wyoming county, which produce building stone for the general market. Numerous small quarries are found in Otsego, Chemung, Tompkins, Tioga, Schuyler, Steuben, Yates, Alleghany, Cattaraugus and Chautauqua counties.

Production of sandstone. The accompanying tables give the production of sandstone during the last two years, divided according to bluestone and other kinds.

There was a very large falling off in the value of the output last year, the returns showing the lowest aggregate reported at any time since the statistics of the industry have been collected by this office. The combined value of both bluestone and sandstone amounted to $955,063, as compared with $1,451,796 in 1910, a decrease of $496,733 or nearly 35 per cent. The value reported in 1909 was $1,839,798. The industry has thus declined nearly 50 per cent in the two years.

All districts in which sandstones are quarried have felt the effects of the depression, but the greatest falling off has been in the bluestone quarries which produce chiefly curb and flagstones. The value of the bluestone output in 1911 was $614,334 against $1,037,637 in 1910 and $1,301,950 in 1909. Of the total for last year, curb and flagstone constituted $337,300, as compared with $385,825 in 1910 and $608,116 in 1909. The value of bluestone used for building purposes amounted to $270,284 against $351,603 in 1910 and $298,631 in 1909. The large decrease in crushed stone last year was due to the completion of a large enterprise in the Hudson river district.

Sandstone other than bluestone, constituted a value of $340,729 against $414,159 in the preceding year and $537,839 in 1909. The showing was thus comparatively better than in the bluestone trade. Orleans county reported a product valued at $255,862 as compared with $332,382 in 1910 and $385,281 in 1909.

Production of sandstone in 1910

DISTRICT	BUILDING STONE	CURBING AND FLAGGING	PAVING BLOCKS	CRUSHED STONE	RUBBLE, RIPRAP	ALL OTHER
Bluestone						
Hudson river........	$26 689	$164 593	....	$200 000	$42 000	$500
Delaware river.......	33 965	212 463	....	....	55 010	170
Chenango co.........	74 985	7 879	....	....	1 165	....
Wyoming co.........	208 444	....	....	....	327	237
Other districts........	7 520	890	....	790	....	10
Total bluestone...	$351 603	$385 825	....	$200 790	$98 502	$917
Sandstone						
Orleans co...........	$23 403	$83 539	$202 773	$4 003	$14 869	$3 755
Other districts........	12 402	10 768	26 080	20 615	6 125	5 827
Total sandstone..	$35 805	$94 307	$228 853	$24 618	$20 994	$9 582
Combined total...	$387 408	$480 132	$228 853	$225 408	$119 496	$10 499

Production of sandstone in 1911

DISTRICT	BUILDING STONE	CURBING AND FLAGGING	PAVING BLOCKS	CRUSHED STONE	RUBBLE, RIPRAP	ALL OTHER
Bluestone						
Hudson river........	$14 377	$123 189	....	....	$560	$200
Delaware river.......	31 775	204 629	....	....	1 775	1 245
Chenango co.........	72 933	9 482	....	....	250	1 210
Wyoming co.........	145 519	....	....	$600	910	....
Other districts........	5 680	....	....	....	....	....
Total bluestone...	$270 284	$337 300	....	$600	$3 495	$2 655
Sandstone						
Orleans co...........	$21 395	$83 519	$145 575	$1 081	$4 257	$35
Other districts........	25 892	10 228	16 645	22 202	6 913	2 987
Total sandstone..	$47 287	$93 747	$162 220	$23 283	$11 170	$3 022
Combined total...	$317 571	$431 047	$162 220	$23 883	$14 665	$5 677

TRAP

The quarrying of trap is a somewhat specialized branch of the stone industry which may be treated with advantage under a separate head. Trap is not a distinct rock type, but the name properly belongs to the fine-grained, dark-colored igneous rocks that occur as intrusive sheets or dikes. In mineral composition it differs from the other igneous rocks classed in the trade as granite, by the prevalence of lime-soda feldspars and higher percentages of the lime, magnesia and iron minerals and correspondingly lower amounts of silica, with little or no free quartz. The name is sometimes applied to fine-grained igneous rocks of granitic or syenitic composition and even to rocks of sedimentary derivation, but such usage is misleading and indefensible.

The particular value of trap is due mainly to its hardness and toughness. Its fine, compact homogeneous texture gives it great wearing powers and it is eminently adapted for road metal and for concrete of which heavy service is required. It has been used to some extent in this State as Belgian blocks. As a building stone it finds very little application, probably on account of its somber color. The expense of cutting and dressing trap is also an obstacle to its employment for building or ornamental purposes.

The trap quarried in New York is properly a diabase, made up of plagioclase feldspar in lath-shaped crystals and pyroxene as the main constituents, and amphibole, olivine and magnetite as subordinate minerals. The largest occurrence is represented by the Palisades of the Hudson, which begin near Haverstraw and extend southward into New Jersey. The Palisades represent the exposed edge of a sill or sheet of diabase intruded between shales and sandstones of Triassic age. The sheet is from 300 to 800 feet thick and about 70 miles long. Most of the trap quarried in this State has been obtained from this region, chiefly from the vicinity of Haverstraw and Nyack, but to some extent from near Richmond, Staten Island, where the sheet has its southern termination. Smaller occurrences of diabase are found in the Adirondacks and the bordering area. There are countless numbers of trap dikes in the interior of the Adirondacks, but few have any considerable thickness and in general they are too remote from the market to be profitably quarried. In the outlying region the dikes at Greenfield, Saratoga county, and at Little Falls, Herkimer county, are the most notable. Quarries have been opened at the former locality and the trap is crushed for road metal.

The production of trap in 1911 amounted in value to $899,414, a small decrease from the total of $909,006 reported in the preceding year. Most of the output was employed for road metal and the quantity thus used was 850,322 cubic yards valued at $696,367. Crushed stone for other purposes chiefly concrete and railroad ballast amounted to 267,930 cubic yards valued at $199,797. The building stone had a value of $3250. Altogether there were 7 firms represented in the industry, of which 6 operated quarries in Rockland county, and 1 the quarry at Greenfield, Saratoga county. The Manhattan Traprock Co. of Nyack discontinued operations during the year having disposed of its quarry property to the Palisades Park Commission.

The future of the trap industry in the Palisades region is involved with the plans for the creation of the park which has received legislative approval in both New York and New Jersey. It is possible that all quarrying operations may eventually be brought to an end. Thus far the only company that has withdrawn from business is the one mentioned, which worked quarries on Hook mountain, north of Nyack.

Production of trap

MATERIAL	1910		1911	
	CUBIC YARDS	VALUE	CUBIC YARDS	VALUE
Crushed stone for roads....	1 000 187	$766 733	850 322	$696 367
Crushed stone for other purposes....................	185 493	122 198	267 930	199 797
Other kinds...............	100	75	185	3 250
Total................	1 185 780	$909 006	1 118 437	$899 414

TALC

The talc mines in the Gouverneur district were quite active last year, though their output was somewhat curtailed by the impairment of mill capacity incident to the long period of dry weather in the late summer and fall, a condition that has been repeated during each of the last three seasons. The production amounted to about 65,000 short tons, all shipped in ground form and mainly, as heretofore, for use in paper manufacture. Prices averaged nearly the same as in the previous year, or about $8.50 a ton; the prevailing quotations for paper stock were between $8 and $9, with a slight reduction for the coarser or inferior grades used for other purposes.

Some interesting developments have taken place in the district during the year. The most important, perhaps, was the entrance of the Uniform Fibrous Talc Co. into the field of commercial operations. This company had been engaged for the last two years in the opening of a mine near Talcville and the erection of a mill and hydro-electric power plant; it began active production in January 1911. The body of talc that has been developed was long neglected on account of the unpromising appearance of the outcrop, but the explorations in depth have demonstrated the existence of a good grade of mineral over a width of 30 feet or more as shown by some of the stopes. Both fibrous and foliated varieties are found, with sufficient of the former to give the mill product the desired quality for the usual commercial applications of the Gouverneur talc.

The present mill, a fire-proof concrete and steel structure, is only partly equipped, being about one-half the capacity that can be obtained when the full complement of machinery is in place. The process of grinding differs somewhat from that employed in the other mills of the district and will be described elsewhere in this article. The power plant that generates the electricity by which both mine and mill are operated is situated on the west branch of the Oswegatchie river, about a mile distant. The dam and power house are built of reinforced concrete. A twin turbine direct connected to a 75 -K.W. alternator supplies the present requirement of power, but a second unit of similar capacity can be added if needed.

The Ontario Talc Co. continued to operate the Potter mine which is now in shape to supply a steady output. The mine is opened on two levels for a horizontal distance of 300 feet, and the shaft is being sunk in preparation for another level. The thickness of the body ranges from 15 to 25 feet or more, with very little waste rock exposed in the workings. It yields a white and very uniform product in which there is a large proportion of fiber. A feature of the mine is the occurrence of considerable masses of the long fiber variety that much resembles asbestos. The mill of the Ontario Talc Co. is about a mile south of the mine near Fullerville, on the west branch of the Oswegatchie. It is operated by a local water power which will probably be supplemented by other supply in the near future, as the company intends to enlarge the milling capacity. Improvements to that end are now under way.

The other producer in the district, the International Pulp Co., made its usual large output, though it concentrated its attentions upon fewer properties than in the previous years. Of the mines owned by the company only three were steadily worked, these including No. 2½ and No. 3 at Talcville and a new mine which has been opened in the vicinity of the old Wight mine in the southwestern section of the district. The mine formerly worked by the United States Talc Co. and taken over by the International Pulp Co. in the recent consolidation was closed down during the year. This has been one of the most productive and best known mines in the district. Little talc was taken from the Arnold and Balmat mines of the old Union Talc Co. The company operated the new No. 6 mill which has a capacity of about 125 tons a day, as well as No. 3 and the Columbia mill. It has recently converted No. 4 mill at Hailesboro into a power plant.

Outside of the Gouverneur district the only talc occurrence that received attention during the year was that near Natural Bridge in Lewis county, mentioned in the preceding issue of this bulletin as under development by the St Lawrence Talc and Asbestos Co. The property is situated about one mile northeast of Natural Bridge in a belt of crystalline limestones and schists that parallels the St Lawrence county district, from which it is 10 or 15 miles distant. The talc, so far as opened, belongs to the massive and platy varieties rather than to the fibrous mineral so characteristic of the Northern belt. There appears to be more or less serpentine in close association with it. Tremolite was observed in a boulder outcrop near the mine. A vertical shaft has been put down on the property, and a crushing plant and mill were under construction last year.

THE GOUVERNEUR TALC DISTRICT

This description of the St Lawrence talc mines is intended only as a sketch of the principal features surrounding the occurrence of the deposits and their industrial utilization. The information on which it is based has been taken largely from published sources, though with such revision as to make the treatment representative of present conditions.

General geology. The investigations of the geology of this section have been carried out mainly by C. H. Smyth, jr. The work hitherto has been in the way of a reconnoissance, as there have been no adequate maps with which to conduct detailed studies of the region which is very involved in its structural and stratigraphic features. The rock formations belong, however, to the same general classes that compose the central Adirondack region and have been described at length in the several areal reports issued by the State Museum.

The talc deposits are immediately associated with crystalline limestones and schists of Grenville age. These occupy belts that have a northeast-southwest trend in conformity with the general structural arrangement throughout the Adirondacks. One of the largest belts begins in the town of Antwerp, Jefferson county, and crosses the towns of Gouverneur and De Kalb, St Lawrence county. It is of considerable economic importance in connection with the marble quarries at Gouverneur. A second belt some 12 miles long and from 1 to 3 miles wide is found a few miles to the east in the towns of Fowler and Edwards. It is this area that contains the fibrous talc deposits. A third belt to the south and east of the latter and lying across the St Lawrence-Lewis county line includes the Natural Bridge talc occurrence that has been recently under development.

The limestones are bordered by members of the Adirondack gneisses, some of which are light in color and have the composition and appearance of slightly modified granites and diorites. A very prominent member in the stretch between Gouverneur and the talc district is a dark hornblende variety which is usually well laminated and garnetiferous and is injected by light red granite. In places the granite forms a branching network that incloses the darker rock in its meshes, producing a mosaic pattern. These granite injections are no doubt offshoots of some of the larger bodies of that rock, while the darker gneiss may belong to the sedimentary series. Of the general relations of the gneiss group it can be said that the igneous types are apparently the youngest and are all later than the limestones. It is not clearly demonstrated as yet whether any of the gneisses in the region are older than the Grenville.

Occurrence of the talc. The talc deposits occur along minor belts within the Grenville limestones and schists. They are locally called veins and have been described as such by some writers, though they have nothing in common with mineral veins, being layers or beds included within the limestones. They have the same strike and dip as the latter and show a fair degree of regularity and persistence. In thickness they range from seams of a few inches up to 50 feet or more. The dip is uniformly toward the northwest at angles that vary usually between the limits of 30° and 60°.

The associated schists are mainly composed of tremolite, but in some places carry considerable quartz. They are singularly free from other minerals. The tremolite is white or light gray in color and is usually developed in finely fibrous individuals which when felted form a compact and tough rock. The pink variety known as hexagonite is of limited occurrence. Bands and irregular masses of the tremolite occur within the talc deposits, and the immediate walls generally consist of the schist, the border being marked by alternating layers of talc and schist.

The association is suggestive of the derivation of the talc which has been the subject of study by C. H. Smyth, jr.[1] The tremolite is no doubt the parent mineral. As explained by Professor Smyth, the limestones were originally impure calcareous sediments and by metamorphic influences have taken on a crystalline character and became impregnated with silicates. Certain limestone beds seem to have contained sufficient magnesia and silica to permit their complete transformation to tremolite, forming a tremolite schist, while other layers, with a preponderance of lime have undergone a partial change, showing scattered crystals and aggregates of silicates within the limestone. The subsequent change of tremolite to talc is the result of weathering and takes place through the agency of ground waters holding carbon dioxid. The alteration may be formulated chemically as follows: $CaMg_3Si_4\ O_{12} + H_2O + CO_2 = H_2\ Mg_3Si_4\ O_{12} + CaCO_3$. The change is accompanied by an increase in volume of talc and calcite amounting to 25.61 per cent, though if the talc alone is considered there is a decrease of .83 per cent as compared with the tremolite. There is little or no calcite in the talc, so that it probably has been removed with the progress of the alteration.

The talc is really a pseudomorph after the tremolite and it is due to this that it possesses a fibrous character. Microscopic examination of specimens from almost any of the mines will show a little residual tremolite in the centers of the fiber aggregates, and in some samples there is a very considerable proportion of unaltered mineral. Foliated talc accompanies the fibrous variety, being more abundant apparently the farther the process of alteration has gone. It is of course a separate development deposited by the circulating waters which have taken the materials of the schist into solution.

The view that the tremolite has been formed by metamorphism from the ingredients of the limestones without addition of material from other sources is perhaps the least conclusive part of the explanation as given. This entails a rather unusual chemical composition that is hardly in conformaty with the character of the limestones in the district. As a rule they are not particularly silicious or impure. An alternative to that view, which would seem equally probable in the circumstances, may be found in the introduction of silica and magnesia along certain beds by underground circulations after the limestones were formed.

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[1] Report on four townships in St Lawrence and Jefferson counties, N. Y. State Mus. Rep't 47, 1894, p. 491–515. Also, Report on the Talc Industry of St Lawrence County, N. Y. State Mus. Rep't 49–2, 1898, p. 661–71.

It is of interest to note that a belt of metallic ores is found in the same limestones on the footwall side of the talc beds. The ores include zinc blende, pyrite and hematite and occur at intervals from Sylvia lake on the southwest to beyond Talcville. They have undoubtedly been deposited by solutions subsequent to the formation of the limestones, and from the similar associations it seems reasonable to connect their introduction with the suggested mode of genesis of the tremolite.

General characters. The fibrous talc is the predominant variety and the usual grade consists of the same felted mass of fine fibers that characterizes the tremolite schist. The fibrous nature is very persistent and can be seen by the microscope to exist even in samples that appear to the unaided eye as massive. Foliated talc, that is the crystallized variety, occurs more specially in the mines on the southwestern end of the belt. It is found as intercalated seams between the fibrous talc.

The fibrous variety is commonly known as agalite, whereas the name rensselaerite is often applied to the foliated mineral. The latter designation seems to rest upon a mistaken identification. The type specimens of rensselaerite collected by Ebenezer Emmons show it to be a mineral of the serpentine family, and to be an alteration of pyroxene.

The color of the talc is white or light gray, with a greenish tint in the foliated variety. The freshly mined material bleaches to a lighter shade on exposure to the air through the evaporation of the mechanically held water. Near the surface the deposits show discolorations from iron and organic matter, but at a depth usually of 40 or 50 feet they pass into commercial rock.

There is no uniform practice followed in selecting or grading the talc before it is sent to the mill. In most mines the foliated talc forms such a small percentage of the average that it does not influence appreciably the quality of the ground product. Certain mines in the town of Fowler produced at one time considerable quantities of this variety, which were sorted out and milled separately. The principal attention is directed toward the character of the material with regard to gritty impurities. It is aimed to leave the gritty talc in the walls and pillars and to send only the milling grade to the surface. The best of the mine output is ground for paper stock, as any appreciable amount of grit affects the sale of the talc in the paper trade.

Mining of talc. The mines are situated along the outcrop of the beds which are included in the section from Sylvia lake in the town of Fowler to near the village of Edwards. Most of the mines have been opened in the northeastern part near Talcville, where there are between 10 and 15 different workings, many of them now abandoned. The chief producers in this section of late years have been the mine of the United States Talc Co., now a part of the International Pulp Co., and No. 2½ and No. 3 mines of the latter company. The Uniform Fibrous Talc Co. has a mine just west of Talcville. The Potter mine of the Ontario Talc Co. is in the central part of the district on the west branch of the Oswegatchie river below Fullerville. On the southwest end of the belt near Sylvia lake are the mines formerly worked by the Union Talc Co., including the Balmat, Arnold, and Wight mines, and the new mine recently opened by the International Pulp Co.

Many of the mines are worked on a leasing system, the operators paying a certain royalty to the owner for each ton of talc extracted. The average royalty is about $.75, which is to be considered as very high for such material.

Mining is carried on entirely by undergound methods. The general practice in the district does not differ materially from that employed in working ore deposits that are similarly situated, though of course the soft and slippery nature of the material necessitates that the pillars left for roof support should be of large size. The workings are reached through inclines carried down on the footwall. In case the bed is not over 15 feet or so thick, a single drift is run from either side of the incline at intervals of from 50 to 75 feet. The drift is carried nearly the full width of the bed and connected with the level above at short intervals by raises, after which the talc is removed between the levels, leaving pillars 25 feet or more square to support the roof. With a bed of greater thickness two drifts may be run on the same level, leaving a wall of talc between to assist in supporting the roof.

Drilling is mostly by machines of the percussion type and the rock is blasted by dynamite. It splits readily along the cleavage planes. The large blocks or slabs from blasting are reduced by sledges to a size convenient for handling. From the stopes the talc is loaded into cars and run out to the incline where it is dumped into skips and hoisted to the surface.

Preparation for the market. The processes in use for grinding and preparing the talc have been gradually evolved out of long continued experimentation. It is said that the first prepared talc shipped from the district was ground in a grist mill. With the discovery of the value of the fibrous variety as a paper filler, attention was directed to the methods of treatment which have been perfected until capable of producing the desired quality and uniformity of grade.

The mills, all of which are run in connection with the mines, number 7 or 8 in all. They have a combined capacity of between 75,000 and 100,000 tons of prepared talc a year. They are situated along the Oswegatchie river in the stretch between Gouverneur and Edwards, the sites being selected with reference to water power facilities. The mines of the International Pulp Co. at Talcville ship their product by railroad to the mills at Hailesboro.

The reduction of the talc is accomplished in several stages. The lump talc as mined is first broken in a jaw crusher of the Blake type. The product then goes through a cone grinder or through rolls where it is reduced to .5 inch or less. In the third stage the crushed talc may be ground between buhrstones of special manufacture or in a centrifugal grinder of which the Griffin mill is a common type. The talc is then passed through a bolt of about 60 mesh and goes to the finishing cylinders, or the finest material may be separated by air currents which blow it into settling chambers and then forms one of the grades for the market. The common practice is to make the final reduction in revolving cylinders charged with pebbles. The Alsing cylinder is the one generally used and is from 8 to 10 feet long and 6 feet in diameter. It is lined with porcelain brick. It is turned from 20 to 25 times a minute. The charge consists of 1 ton of talc and 3 tons of flint pebbles. The grinding of a single charge takes from 2 to 5 hours, depending upon the grade of product that is desired. The fibrous character of the talc is maintained throughout the grinding to the end product, so that it is difficult to size the ground talc by screening; consequently the degree of fineness is regulated entirely by the duration of the final grinding process.

In the new plant of the Uniform Fibrous Talc Co. the Hardinge conical mill is employed in preparing the talc for the finishing process. The crude rock is first passed through a jaw breaker which reduces the lump talc to about 1.25 inch size; and then the product is screened and fed into the Hardinge mill where it is ground to pass a 10 mesh screen for the cylinders. The latter are of the usual intermittent type.

Tube mills of large size, such as are used in the fine grinding of cement and ores, have been installed in one or two plants. They take the place of the Alsing cylinder. They have the advantage over the latter of being continuous in regard to feed and discharge, but are more difficult to regulate so as to give the desired finish to the product.

A coarser grade known as buhr stock is produced by omitting the last stage of grinding in the Alsing cylinder. This is used as a substitute for asbestos in the manufacture of asbestos paper and packing. The ground talc, or mineral pulp as it is called, is put up in paper sacks of 50 pounds each, or in cloth bags of 200 pounds. Shipments are made by the Gouverneur and Oswegatchie Railroad, near the line of which most of the mills are located. Prices are usually quoted from Gouverneur.

Cost of production. The conditions vary so much in the different mines and mills that it is impossible to fix any average basis for estimating the costs of production. The mining and milling operations are perhaps the least variable factors of all, and these may be figured approximately at from $1.50 to $2 a ton. Royalty is an important item in the leased mines; it is usually fixed at about $.75, but may be as low as $.25. The haulage from mine to mill and from the mill to the shipping point is a heavy tax in some cases, as the country is rough and the roads are very poor. This may amount to as much as $1.50 or $2 a ton. The cost of package is about $1.

Uses. The fibrous talc is mainly used in the paper trade as filler for book and writing paper and to a considerable extent for newspaper. It is more readily incorporated with the paper stock than clay and at the same time has a beneficial influence upon the strength of the paper. The manufacturers of gypsum wall plasters are consumers of the talc which takes the place of hair, wood fiber or asbestos in these plasters. Among the minor uses are in the manufacture of waterproof paints and steam pipe coverings.

Chemical analyses. The following analyses indicate the composition of the talc from this district. No. 1 and No. 2 are from Dana's System of Mineralogy. No. 3 is quoted from Professor Smyth's article. For No. 4 the writer is indebted to Mr A. McLintock of the Uniform Fibrous Talc Co.:

	1	2	3	4
SiO_2	60.59	59.92	62.10	68.9
Al_2O_3	.13	.50	......	1.3
Fe_2O_3	......			
FeO	.21	.76	1.30	......
MnO	1.16		2.15	......
MgO	34.72	31.37	32.40	26.6
CaO	......	.57	......	.8
Na_2O	......	.48	......	......
H_2O	3.77	6.25	2.05	2.4
	100.58	99.85	100.00	100.00

Production. The first shipments of talc from the district were made during the seventies of the last century. The earliest regular operations are said to have been instituted by a mineralogist named Minthorne who formed a company for mining and milling talc on the Wight farm in the town of Fowler. By the year 1880 shipments were made in considerable quantity. The production from that date as given in the volumes of the *Mineral Industry* or reported by this office have been as follows:

Production of talc in New York

YEAR	SHORT TONS	VALUE	YEAR	SHORT TONS	VALUE
1880	4 210	$54 730	1896	46 089	$399 443
1881	5 000	60 000	1897	57 009	396 936
1882	6 000	75 000	1898	54 356	411 430
1883	6 000	75 000	1899	54 655	438 150
1884	10 000	110 000	1900	63 500	499 500
1885	10 000	110 000	1901	62 200	483 600
1886	12 000	125 000	1902	71 100	615 350
1887	15 000	160 000	1903	60 230	421 600
1888	20 000	210 000	1904	65 000	455 000
1889	23 476	244 170	1905	67 000	519 250
1890	41 354	389 196	1906	64 200	541 600
1891	53 054	493 068	1907	59 000	501 500
1892	41 925	472 485	1908	70 739	697 390
1893	36 500	337 625	1909	50 000	450 000
1894	50 500	454 500	1910	65 000	552 500
1895	40 000	320 000	1911	65 000	552 500

ZINC

Work on the zinc blende occurrence near Edwards, St Lawrence county, was resumed last year. The Northern Ore Co. recently succeeded to the ownership of the property which had lain idle since 1904 owing to legal complications. It began systematic development of one section of the deposit on April 1st and continued active operations throughout the remainder of the season. As a result the company had at the close of the year about 8000 tons of milling ore on the surface, besides a much larger quantity blocked out underground. Shipments of several hundred tons of selected blende were made for experimental purposes, the first commercial product ever sent to a zinc smelter from this State.

The developments on the property give hope that a substantial mining industry may be established. They are considered sufficiently encouraging by the company to warrant the erection of a milling plant, on which work has already been started at Edwards. The mill is planned for a capacity of 50 tons crude ore a day, and present expectations are that it will turn out concentrates averaging about 60 per cent zinc. Though about one-third of the ore developed last year would bear shipment in crude state, the distance from the zinc-smelting districts makes concentration an advantage and probably all of the output will pass through the mill. This will enable the production, also, of a valuable by-product in the form of pyrite. Some of the ore, furthermore, carries an appreciable quantity of galena which will doubtless be saved by the mill treatment.

Only a limited area of the mineralized zone has been explored as yet. The work during the past year was directed to the underground exploration of a single outcropping lens that had been previously uncovered and followed to a depth of 40 or 50 feet. This has been developed through an inclined shaft following the dip of the ore and by a series of drifts and crosscuts. At the time of the writer's visit to the property in June 1911, the shaft had been sunk about 100 feet and showed a continuous band of ore all the way from 4 to 7 feet thick. According to recent information communicated by A. J. Moore, manager of the Northern Ore Co., at Edwards, the conditions have continued favorable with the further progress of the shaft and additional ore bodies have been encountered in some of the crosscuts.

The ore lens that has been under development is remarkably high in grade, the whole mass being almost solid blende and pyrite.

There is considerable variation in the proportions of the two minerals, though blende is much the more common and in some parts of the deposit is practically the only ingredient. Assays of the richer material show from 40 to 50 per cent zinc. The blende is black, nontransparent, and apparently carries relatively large amounts of iron.

The general features of the ore occurrence in the Edwards section were presented in the issue of this report for the year 1905, but in view of the discoveries that have since been made, it may be of interest to enter upon their discussion here.

The existence of the zinc in this part of St Lawrence county has been known since the early part of the last century and is mentioned briefly by Ebenezer Emmons in his Report on the Geology of the First District, published in 1838. Some attempts were made to work the ores in the early days, as shown by the excavations on the Balmat property which are said to have been undertaken for the purpose of extracting the lead and silver values rather than the zinc. The intimate mixture of galena, blende and pyrite proved no doubt a rebellious material to treat by the methods then available; at any rate mining was soon abandoned. The present interest in the deposits dates from about 1902 when the attention of local mining men was attracted to some specimens of rich blende that were uncovered in the Edwards locality about 12 miles northeast of the old Balmat prospect. These appeared so promising that leases were secured on the property and work was begun under the direction of T. M. Williams. After a short period of exploration which showed promising results the company became involved in legal difficulties that have but recently been removed, and nothing was done in the interval from 1904 to 1911.

The ores are found along a well-marked zone which parallels the talc deposits and lies on the footwall of the latter. The wall rock is crystalline limestone of the same nature as that inclosing the talc; it belongs to the Grenville series, widely represented on this side of the Adirondacks. The limestones are interstratified with thinly bedded quartzose schists, tremolite schists and heavier hornblende gneisses, and the whole series has been invaded then and there by granitic intrusions. The limestones and included schists of this particular district are exposed in a belt that extends from near Sylvia lake, town of Fowler, on the southwest to a point a little north of Edwards village, on the northeast. They represent regionally metamorphosed and compressed sedimentaries which are among the very earliest of the Adirondack formations. The granite is found in dikes, stringers and irregular bodies and belongs probably to one or more of the great invasions of that rock which took place in the Adironacks at different times in the Precambric period. Both fine-grained and pegmatitic varieties occur. The other important Adirondack intrusives including syenite, gabbro, diabase etc., are absent so far as known. There are no Paleozoic strata though they begin a few miles to the west with horizontal beds of Potsdam sandstone. They no doubt extended over this area at one time and reached far into the interior of the Adirondacks, but have been planed off by erosion.

The limestones and schists have a northeasterly strike and are upturned at a high angle, the dips being usually 45° or over toward the northwest. The limestone is coarse and carries abundant silicates. The latter in places constitute the greater part of the mass. The tremolite schists from which the talc beds are derived represent the extreme stage in the silication of the limestones. The quartzose schists and hornblende gneisses are probably metamorphosed products of impure sandstone and shales.

The zinc ores at Edwards occur in a mass of impure serpentinous limestone which forms a low ridge just north of the Oswegatchie river on the road to Trout lake. On the north end of the ridge there is a shallow open cut showing a band of mixed blende and limestone about 15 feet thick. The blende occurs in irregular bunches which apparently are the brecciated fragments of what was once a more or less solid lens or band of the ore. There is evidence of intense compression which has forced the limestone into the fractures and recemented the mass. The limestone for some distance away from the lens is impregnated with blende so as to form a lean ore. The occurrence has not been tested for any considerable depth. Several other showings of ore are found on the sides and top of the ridge to the south of this opening. About 1000 feet away and on the opposite or eastern side of the ridge is the one which has been explored during the past season, as above mentioned. In this place the ore shows less evidence of compression or disturbance and admixture with limestone. The lenses also have well-defined walls. The blende is finely granular without any trace of crystal form. The pyrite is sprinkled through the mass in rounded grains which range up to one-fourth inch in diameter and occasionally show a cubical development. Barite is found in some quantity in the walls. On the weathered outcrop it shows prominently as a spongy aggregate that was first mistaken for smithsonite.

In the interval between Edwards and the Balmat prospect there have been several discoveries of ore which, however, have not been sufficiently prospected to reveal anything definite as to their extent. They indicate that the mineralization follows a fairly definite zone parallel and in proximity to the talc deposits.

The Balmat occurrence is described briefly by Emmons in the report already referred to as " a remarkable occurrence of the sulfurets of zinc, lead and iron in about equal proportions . . . . The direction of the vein is north-northeast and south-southwest and the width about 8 inches, but not well defined. The sulfurets traverse a bed of serpentine 40 to 50 feet wide. The occurrence of zinc intermixed with lead is not favorable to the reduction of the latter." There are two shafts on the ore body about 1000 feet apart. The outcrop of the ore where it is revealed shows a vein or band up to 3 feet thick. Near the south shaft a short adit has been driven into the ore from the side hill, the only part of the workings now accessible, and shows the vein at this point to be from 4 to 5 feet thick. There is much more galena in this occurrence than at Edwards and usually more pyrite.

Another ore locality in the southwestern section is on the lands owned by J. H. McLear, south of Little York and near Sylvia lake. The deposit was originally opened with a view to the working of iron ore which occurs in the form of specular hematite. Some of it was used in the Fullerville furnace nearby. The hematite occurs in a lens of uncertain size, some of it being nearly pure and other parts charged with pyrite and blende. The sulfides are specially developed along one of the walls. Specimens from this part have assayed above 20 per cent zinc. There has been no recent work done on the deposit.

From the present stage of development there is insufficient evidence to base any prediction as to the possibilities of the district as a producer of zinc ore. It is evident, however, that a small output is assured by the results obtained at Edwards where thus far only a single outcropping has been attacked. If the developments there continue as favorable during the coming season as they have been in the past they will go far toward proving the persistence of the deposits in depth which is of most importance to the future of the district and about which least is now known. In the case of such issue there will be much encouragement, also, for the extension of exploration to other parts of the mineralized area. Though the deposits are narrow as compared with those found in the important zinc-producing districts of other states, they possess an advantage over most in their average tenor. They are furthermore exceptionally situated for economic exploitation, with convenient shipping facilities, cheap electric power available, and efficient labor to be had in the district.

The derivation of the ores is an interesting problem that need not be given detailed treatment in this place. The apparent close association of the zinc and talc deposits may be pointed out as a feature of practical importance to exploration and it seems very likely to reflect some underlying geological principle. The geological relation, if such exists, is probably between the tremolite and the zinc ores rather than between the latter and the talc itself which is an alteration product of the tremolite. The extensive development of tremolite in belts within the limestone is regarded by the writer as the work of underground circulations which have brought in silica and perhaps also a part of the magnesia necessary for the conversion of the lime carbonate to the magnesia-lime silicate. These circulations, it is reasonable to suppose, may have carried other ingredients including zinc, lead and iron which have gone to form the metallic deposits.

The zinc deposits have the general appearance of replacement bodies rather than the fillings of open fissures or cavities. In most places their boundaries are not clean cut but are in the nature of transition zones shading off gradually into the limestone. The lens of compact ore which has been under recent development shows, however, fairly sharp contacts. The internal structures are not those characteristic of open-fissure fillings as there is no appearance of banding or crusts or drusy cavities lined with crystallized minerals. The compact granular nature of the ore suggests deposition at considerable depth and under pressure. In that event it may be inferred also that the deposits are very old, possibly of Precambric age. Erosion in this part of the Adirondack region seems to have been comparatively slight since Cambric times and has been mainly effective in removing the mantle of Paleozoic sediments which now are only found in the bordering area.

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New York State Museum

JOHN M. CLARKE, Director

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These reports are made up of the reports of the Director, Geologist, Paleontologist, Botanist and Entomologist, and museum bulletins and memoirs, issued as advance sections of the reports.

Director's annual reports 1904–date.

1904. 138p. 20c.
1905. 102p. 23pl. 30c.
1906. 186p. 41pl. 25c.
1907. 212p. 63pl. 50c.
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1910. 280p. il. 42pl. 50c.
1911. 218p. 49pl. 50c.

These reports cover the reports of the State Geologist and of the State Paleontologist. Bound also with the museum reports of which they form a part.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, 8vo; 2, 14–16, 4to.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–4, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

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16	1	20	.50	[*See* Director's annual reports]	

Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

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5	.25	13	*Out of print*	22 (" 110)	.25
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7	.20	15 (" 31)	.15	24 (" 134)	.35
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Botanist's annual reports 1867–date.

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Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), in volume 4 of the 56th (1902), in volume 2 of the 57th (1903), in volume 4 of the 58th (1904), in volume 2 of the 59th (1905), in volume 1 of the 60th (1906), in volume 2 of the 61st (1907), 62d (1908), 63d (1909) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum Memoir 4.

Museum bulletins 1887–date. 8vo. *To advance subscribers, $2 a year, or $1 a year for division* (1) *geology, economic geology, paleontology, mineralogy; 50c each for division* (2) *general zoology, archeology, miscellaneous,* (3) *botany,* (4) *entomology.*

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The divisions to which bulletins belong are as follows:

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3 Economic Geology
4 Mineralogy
5 Entomology
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7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 "
12 "
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16 Archeology
17 Economic Geology
18 Archeology
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25 Botany
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—— & Clarke, John M. v. 7 Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. 64 + 236p. 46pl. 1888. Cont. supplement to v. 5, pt 2. Pteropoda, Cephalopoda and Annelida. 42p. 18pl. 1888. $2.50.

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—— & Clarke, John M. v. 8 pt 2 Paleozoic Brachiopoda. 16 + 394p. 64pl. 1894. $2.50.

Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. 8vo. 1853.

Handbooks 1893–date.

New York State Museum. 52p. il. 1902. Free.

Outlines, history and work of the museum with list of staff 1902.

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Brief outline of State Museum work in paleontology under heads: Definition; Relation to biology; Relation to stratigraphy; History of paleontology in New York.

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Classification of New York Series of Geologic Formations. 32p. 1903. *Out of print.* Revised edition. 96p. 1912. Free.

Geologic maps. Merrill, F. J. H. Economic and Geologic Map of the State of New York; issued as part of Museum Bulletin 15 and 48th Museum Report, v. 1. 59 x 67 cm. 1894. Scale 14 miles to 1 inch. 15c.

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New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 162

THE LOWER SILURIC SHALES

OF THE

MOHAWK VALLEY

BY

RUDOLF RUEDEMANN

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Hon. Andrew S. Draper LL.D.
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SIR: I have the honor to communicate to you herewith a manuscript entitled *The Lower Siluric Shales of the Mohawk Valley,* with accompanying plates. This work has been prepared by Dr Rudolf Ruedemann, Assistant State Paleontologist, and is the result of careful and protracted observations. I recommend it, subject to your approval, for publication as a bulletin of the State Museum.

Very respectfully
JOHN M. CLARKE
Director

STATE OF NEW YORK
EDUCATION DEPARTMENT
COMMISSIONER'S ROOM

Approved for publication this 15th day of May 1912

A. S. Draper

Commissioner of Education

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New York State Museum

JOHN M. CLARKE, Director

Museum Bulletin 162

THE LOWER SILURIC SHALES OF THE MOHAWK VALLEY

BY RUDOLPH RUEDEMANN

INTRODUCTION

While engaged in mapping the shales of the Saratoga and Schuylerville quadrangles of the State of New York, the writer has found that in order properly to correlate the formations of fossiliferous shales appearing there with the standard formations of the State, it would be necessary to trace their relation to the Utica and Frankfort shales through the Mohawk valley. In beginning this task in Schenectady county, an unexpectedly large and interesting fauna was found in the " Frankfort shale " of that county hitherto considered as practically barren. This discovery promised a safe conclusion as to the as yet unknown faunal and taxonomic relations of the Frankfort shale to the Utica shale on the one hand, and to the Lorraine beds on the other. The close faunistic and stratigraphic relations of the Frankfort shale to the Utica shale were early recognized in the work, and as the writer had previously (title 60[1], page 44) obtained evidence of the different faunal aspect of the " Utica shale " of the lower Mohawk from the typical shale at Utica, it was found desirable to include the Utica shale in the investigations.

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[1] See Bibliography, p. 69.

It was further found that beds formerly considered by the author (op. cit., page 29) as representing one formation (the Magog), had to be divided into two units, the Canajoharie shale and the Snake Hill beds. These beds are not only in juxtaposition about the mouth of the Mohawk, but even intermingled in that much-folded territory, and we originally considered them as both belonging to the Mohawk series and therefore have described also the Snake Hill beds in this paper. Later work has, however, shown that the Snake Hill beds were deposited in the Levis basin upon the Normanskill shale and have been brought to the mouth of the Mohawk and in contact with the Canajoharie beds by the overthrusting and compression of the shales of the Levis basin. We have nevertheless added the description of the Snake Hill fauna in the present paper, first, on account of its present occurrence in the lowest Mohawk valley, then, because of the intermixture of Snake Hill beds with Canajoharie shale, and, finally, because of the faunal similarities suggesting their equivalence. The Snake Hill formation finds, however, its principal development in the area of the Schuylerville sheet, and will therefore be more fully described in the report on that region, soon to be published.

Evidence was soon obtained that the lower part of the Utica shale of the lower Mohawk valley is older than the typical Utica shale and probably of Trenton age, and it would have been desirable to also trace the Trenton limestone from its type section at Trenton Falls to its much smaller section in the lower Mohawk valley. Time was lacking for this undertaking but fortunately Doctor Ulrich has furnished us important data as to the Trenton limestone, and we are glad to acknowledge here our obligation to him not only for this information, but also for advice in the identification of fossils, and many valuable suggestions as to the broader bearings of the problem.

We are also under obligation to Mr David White for the valuable notes on the interesting seaweeds collected in the Schenectady shale (see page 73), to Prof. Bashford Dean, Dr L. P. Gratacap, Dr H. A. Pilsbry for advising us in regard to the problematic fossils from the Schenectady shale, here described (see page 74), to Prof. A. F. Foerste for information regarding certain brachiopods and to Dr E. O. Hovey for the loan of type specimens from the American Museum of Natural History.

HISTORICAL SKETCH

A perusal of the literature shows that the Utica and Frankfort shales have received scanty attention from geologists, quite obviously because they promise little, if any, results, the Utica shale fauna consisting largely of small species difficult of study. The Frankfort shale was declared by Vanuxem to be remarkably deficient in all organic remains excepting graptolites. A fairly full account of the two was given by Vanuxem in the *Geology of the Third District*. This astute observer distinguished the Utica slate and the Frankfort slate; the latter as a subdivision of the Hudson River group or Lorraine (Emmons), the other member being the Pulaski shale. He states that in his district (which included the Mohawk valley) the Utica slate is everywhere underlain by the Trenton limestone and overlain by the Frankfort shale and sandstone; that both the Utica and Frankfort beds enter his district from the first district on the lower Mohawk and are coextensive there, while the Pulaski shale first appears much farther west in Oneida county. The Utica slate is characterized as deep bluish black rock, generally fissile, exhibiting a brownish or dark chocolate color by weathering and associated with thin layers or flags of dark colored impure limestone, especially in the lower part of the mass. As characteristic fossils, that do not come up from the Trenton, are cited:

Triarthrus becki, Graptolites dentatus (either Dipl. foliaceus or Glossogr. quadrimucronatus), a mutation of Trocholites ammonius and Graptolites scalaris (Diplograptus and Climacograptus viewed from in front).

The Frankfort slate is stated by Vanuxem to change by imperceptible gradation from the Utica slate, "yet a separation would seem obvious from the fact that the dark blue or black color of the latter disappears in the usually light color of the former. While the Utica slate alternates at its lower part with thin beds of dark colored impure limestone, the Frankfort slate, on the contrary, alternates with a peculiar sandstone to which Professor Eaton gave the name of rubblestone; and while the Utica slate is calcareous, the Frankfort slate is wholly destitute of calcareous particles." He continues: "Both slate and rubblestone" (greywacke of Eaton, an impure argillaceous sandstone), "lose their bluish color when long exposed, and assume a dull dark gray, green or olive color, which is very characteristic of this rock, and by which it is readily distinguished from the Utica slate, which as before mentioned, changes to a brown." Vanuxem comments on the thinning of the Frankfort beds westward and it is obvious from his remarks (page 61) that he also considered the greater part of the shales in the Hudson valley as of Frankfort age, largely on account of the intercalation of similar rubblestone or greywacke. He describes the Frankfort shale as remarkably deficient in organic remains, stating: "From the eastern end of the Helderberg to Oneida county, I have seen but one fossil shell in the whole mass." Only graptolites are said to be numerous in a few places; this statement, however, refers principally to the shale in the Hudson valley, which we no longer refer to the Frankfort beds. He also found a small specimen of Triarthrus becki and two of Trinucleus concentricus ("Cryptolithus").

In the middle Mohawk valley the Frankfort slate is capped by the Oneida conglomerate, but in the upper valley and to the west of the Adirondack region it is overlain by the Pulaski shale, or rather it is separated from the typical Pulaski shale by an "intermediate area" (Vanuxem, page 64) with a separate fauna which Vanuxem considered a lower subdivision of the Pulaski shales.

Hall, in volume 1, Palaeontology of New York, brought out the fundamental paleontologic data for the formation in question. He distinguished the faunas of the Utica slate and of the Hudson River group, the latter comprising all the horizons of the shales in the Hudson valley, including the Frankfort and Pulaski (Lorraine) beds.

In volume 3, Palaeontology of New York, Hall extended the term Hudson River group to "all the beds from the Trenton limestone to the Shawangunk conglomerate," a conception which was taken up by the textbooks and came into general use.

In an attempt to correlate the Normanskill shale with the Utica formation, Whitfield (title 7) cited several Normanskill graptolites (Didymograptus serratulus, Dicranograptus ramosus, Climacograptus bicornis) from the Utica shale of the neighborhood of Fort Plain in the Mohawk valley as proof of his contention. The writer has shown (1901, 1908) that this view is based on the wrong identification of these graptolites. It had, however, an important influence in inducing later authors to refer a large part of the shales of the Hudson valley to the Utica shale.

Walcott (title 9) in his "Utica Slate and Related Formations," distinguished the Utica epoch from the Trenton and Hudson River epochs and added a considerable number of new types (two species of the sponge genus Cyathophycus, species of graptolites of the genus Dendrograptus, Leptograptus annectans and a few other forms) to the list of hitherto known Utica species. In his "Catalogue of Fossils Occurring in the Utica Slate" (page 34), he brought the Normanskill shale with its graptolites into the Utica shale as an upper division. The geographic distribution of the Utica shale within and outside of New York was fully discussed by him. The presence of passage beds between the Trenton limestone and Utica slate in the region of the type section is also commented upon (page 10). The thickness of the Utica shale, before greatly underestimated, is given as over 600 feet at the type section.

Beecher published in 1883 (title 13) a list of fossils from the black shales near the old Dudley Observatory, at Albany, referring the beds to the Utica epoch and Ford, a year later, recorded the discovery of a few fossils (Graptolithus pristis, Gr. mucronatus, Triarthrus becki and Lingula curta) in the slaty and arenaceous rocks in the vicinity of Schenectady, which on the strength of this evidence he also considers as of Utica age, while the preceding authors (Vanuxem) had referred it to the Frankfort slate, respectively Hudson River shale (Mather, Emmons).

In 1890, Walcott in a paper on "The Value of the Term Hudson River Group," asserted the continuation of both the Utica slate and Frankfort shale into the Hudson valley, thereupon basing his argument for the extension of the term "Hudson River group" to all beds between the Trenton limestone and Upper Siluric. As before, he included the Normanskill shale in the upper Utica epoch or lower Frankfort. The fauna discovered by Beecher at the Dudley Observatory was correlated with the upper Utica and that from the glazed slates at Cohoes (whence Hall in Palaeontology of New York, volume 1, reports Ambonychia radiata, etc.) to the Frankfort shale. The important fact is pointed out that a well drilled at Altamont (Knowersville), 17 miles west of Albany, gave a thickness of 3475 feet for the strata between the Lower Helderberg limestone and the Trenton limestone. On account of its proximity this section allows a good estimate of the great thickness of the Utica and Frankfort shales in the lower

Mohawk region, which is only about 10 miles to the north over a continuous outcrop of Frankfort beds.[1]

Darton did not make any special study of the Utica and Frankfort beds for his "Geology of the Mohawk Valley" (1893).

Of great importance for the present work were the investigations of Prosser and Cumings (titles 33, 44). They described a number of sections through the Utica slate and the Frankfort beds (their Hudson River group) and demonstrated the great thickness of these groups in the Amsterdam quadrangle (Utica 950–1260, Frankfort 1200 +)[2]. Among other things, they made known in the Minaville section a complete transition from the Utica to the Frankfort beds. From the base of the Minaville section a fairly complete section can be obtained along Chuctenunda creek through the Utica down to the Trenton limestone and thus it has been possible for us to study a continuous section from the Trenton to the Frankfort in the lower Mohawk valley. A list of eighteen species is given for the Utica slate at Canajoharie, and a small faunule recorded from the Hudson River shale near the Schenectady pump station, namely, Triarthrus becki, Trinucleus concentricus, Plectambonites, sericeus, Orthis (Dalmanella) testudinaria, Orbiculoidea sp., Monticulipora (Prasopora) lycoperdon, crinoid segments and graptolites.

A few notes on the Frankfort shale sections along Moyer creek near Frankfort (the type section) and Ferguson creek near Utica were published by Theodore G. White in 1899 and the presence of Triarthrus becki, a small Orthis, a small Orthoceras and graptolites recorded in these sections.

Purely paleontologic papers on fossils from the Utica slate of the Mohawk valley were published in the decade of 1890–1900 by Beecher on Triarthrus becki and by Ruedemann on the development of graptolites, and a sessile Conularia. Ruedemann (title 36) also demonstrated that in the Utica shales of the Mohawk valley distinct evidence is found of marine currents following a northeast-southwesterly course.

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[1] The terms Trenton limestone, Utica and Frankfort shales are used in this introduction in their old meaning, not in the restricted conception given to them in this paper.

[2] Cumings (1900, page 462) measured an actual thickness of the Utica slate of 1160 feet in the Adebahr hill section.

In 1901, the author (title 47) in his bulletin on the Hudson River beds near Albany, correlated the Normanskill shale with the lower Trenton and argued on this account for the suppression of the term Hudson River group. He also pointed there (page 560) to the decrease of the thickness of the Trenton limestone eastward in the Mohawk valley and the rapid increase of the "Utica" shale in the same direction. In the following years the author also showed the presence of graptolite zones ranging from the top of the Cambric through the Beekmantown and Trenton to the Utica in the Hudson River shales. A broad belt of shales on the west side of the Hudson overlying the middle Trenton shales and Normanskill shales was still referred to the Utica shale; and the shales at Cohoes and to the west of the Utica belt were in accordance with Hall and Vanuxem correlated with the Frankfort division of the Lorraine group, mainly on the ground of a series of small lamellibranchs obtained about Cohoes and of the supposed upper Utica aspect of the Dudley Observatory faunule.

In 1902 Paleozoic Seas and Barriers in Eastern North America by E. O. Ulrich and Charles Schuchert was published. This very important paper, which apparently has not been sufficiently understood or appreciated by many, has helped greatly in the elaboration of the complex shale problems by pointing to the existence of separate troughs or channels in the shale region (the Chazy and Levis troughs) of New York and to the draining of these channels independently of each other.

Clarke in the Classification of the New York Series of Geologic Formations (title 52) discarded the term Hudson River and distinguished the Utica shale and Lorraine beds as stages of the Cincinnatian; the Frankfort shale, Pulaski and Salmon River being considered as "early terms applied to the local development of these beds in central New York."

In an excellent description of the Geology of Little Falls, Cushing (1905) pointed out the presence of 100 feet of passage beds between the Trenton and Utica. He says: "Lithologically these beds are no more Trenton than they are Utica but are distinctly intermediate in character, and no more to be classed with the one formation than with the other." He mapped them as a distinct unit, and in a later communication to Professor Miller (title 65, page 21) he proposed the term *Dolgeville shale* for these passage beds, considering them a formation "as a shaly eastern representative of the upper Trenton limestone of the type section."

These beds were found by Miller (title 65) to be absent on the Remsen quadrangle which adjoins the Little Falls quadrangle to the west.

The graptolites of the Utica shales and supposed Frankfort beds of the Hudson valley have been fully described by the author in volume 2 of Graptolites of New York (1908). The Utica shale is there characterized as the zone of Glossogr. quadrimucronatus and Climacograptus typicalis. The presence of subzones and the difference of the faunas in different districts especially that between the fauna of Holland Patent and the lower Mohawk is pointed out, and the fact brought out (page 36) that the Utica faunules of the Appalachian trough differ from those of the Mohawk valley by the frequent occurrence of Corynoides calicularis[1] which latter only enters the lower Mohawk valley. The transgression of the Utica shale from the northeast is inferred from the faunal evidence and as corollary of this transgression the conclusion drawn (page 49) that the boundary between the Trenton limestone and Utica shale is not a plane of synchrony, and that the areal restriction of the Corynoides to the lower Mohawk valley may be due to the greater age of the eastern Utica beds and its absence farther west, or to the replacing of the shale by the lower Trenton limestone. The Utica of the Hudson valley is thought to be separated by the Magog shales from the lower Trenton Normanskill shale.

The faunule of the Frankfort shale is described from the supposed Frankfort beds at Waterford and Mechanicville.

In a paper by Grabau on the Physical and Faunal Evolution of North America during Ordovicic, Siluric and early Devonic Time (1909) the relations of the Trenton and Utica are stated as follows:

> The Trenton limestone of America is not a stratigraphic unit, but, as has been repeatedly demonstrated by Ruedemann and noted by many observers, it is the limestone phase of a series which elsewhere is in part or mostly represented by Utica shale. In the Mohawk valley the dividing line between Utica and Trenton is a line constantly rising to the west, the transition being in some cases abrupt, though probably in most cases it is gradual. Ruedemann has pointed out the progressive increase in thickness westward of the limestone, and corresponding decrease in the shale; the former increasing from 40 feet at Saratoga to 430 feet at Utica, and to 954 feet at Rochester, while the latter decreases from 1260 feet to 710 feet to probably zero over the same localities. . . . The

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[1] Erroneously there referred to C. curtus.

various sections clearly show that along the western border of the Appalachians, dark graptolite shales continued to form in Upper Ordovicic time, while westward from this the Trenton limestone represents the calcareous phase of the Utica-Trenton series (see map, figure 8).

In a diagram that accompanies Professor Grabau's paper (op. cit. figure 9), the Utica is represented as wholly replaced by Trenton limestone in the latitude of Rochester and farther west.

In the description of the Remsen quadrangle Miller (title 65) has shown the absence of the Dolgeville beds in the area adjoining the Little Falls quadrangle to the west. He found the Utica to be only 300 feet thick indicating a notable thinning to the northwest from the type section. Two hundred feet of Lorraine beds were observed which were found to be destitute of fossils and are not separated by an exact boundary line from the Utica. There is little doubt that these beds are the Frankfort shale. This decrease is in a later bulletin (title 66) by the same author shown to be steady toward the north. It would also become probable from the same paper that the Frankfort shale with a thickness of about 200 feet continues to the northwest and intervenes there between the Utica shale and Lorraine sandstones and shales with the characteristic Lorraine fauna (page 33).

To the south of New York, in New Jersey, Pennsylvania and West Virginia, the shales which formerly were termed "Utica and Hudson River slates" are now known as Martinsburg shale. The Martinsburg shale of the Mercersburg-Chambersburg quadrangle in Pennsylvania has been described by Stose, and fossil lists given by Ulrich (title 61, page 10). The lowest shale fauna is considered as indicating an age corresponding to that of the lower to middle Trenton of New York, and the highest as comprising species characterizing the Eden shale.

Bassler, in his work on the Cement Resources of Virginia (title 62), the Federal Survey's part of which was done under the official direction of Doctor Ulrich, divides the Martinsburg shale in three divisions, namely, upper Trenton shale, Utica shale and Eden shale, representing the shaly Ordovicic deposits of the Appalachian trough. The Martinsburg is continuous from Virginia through Pennsylvania and New Jersey with the shale belt of New York, and this division of the shales has a direct bearing on that of the shale in the New York part of the Appalachian trough, represented by the shales in the Hudson valley.

Schuchert (1910), in his monumental Paleogeography of North America, refers the Utica of New York as the zone of the Mastigograptus fauna to the top of his Ordovicic period. As characterizing the shale facies of the Trenton in the Atlantic province are cited the Climacograptus caudatus, Corynoides curtus and Magog graptolite zones, while the horizon of the Normanskill shale is correlated with the Black River of New York and Kimmswick of Illinois and Missouri. The Frankfort is correlated with the Edenian and placed in the Cincinnatic period, the Ordovicic period being considered as closed by the Utica emergence. Paleogeographic maps of North America in the late Trenton and Utica stages by Ulrich and Schuchert are given, to which we will have occasion to refer.

A new light has been shed on many problems, here involved, in the Revision of the Paleozoic System by E. O. Ulrich (title 68), the first volume of which appeared after this paper was written, but as much of the information therein published was freely given to the author in the joint field excursions in the Mohawk and Hudson valleys, its principles have been applied to a considerable extent to the questions that arose in this investigation and the conclusive answers obtained are clear evidence of the truth of some of these principles. We have here especially in mind Ulrich's theories of a multiplicity of shallow continental seas and of frequent and periodic migrations of faunas from their permanent oceanic habitats into these inland seas.

In the investigation of the Utica and Frankfort shales in the Mohawk valley, the entire mass of shales between the Trenton limestone at the base and the Upper Siluric rocks on the top were studied in the region from Cohoes at the mouth of the Mohawk to the neighborhood of the city of Utica and of Holland Patent. In the lower Mohawk region for the most part a broad plain of deep drift intervenes between the Mohawk river bluffs and the foot of the Helderberg escarpment; only two sets of sections were therefore accessible in greater numbers, one at the base of the shales in the ravines near the mouths of the southern tributaries of the Mohawk and another in the upper Frankfort beds in the ravines cut into the lower slopes of the Helderberg escarpment. The Chuctenunda creek furnished here the most satisfactorily continuous section, leading from the Trenton limestone to the Schenectady beds. The Canajoharie creek and Flat creek at Sprakers afford two excellent sections through the lower " Utica beds " (here distinguished as

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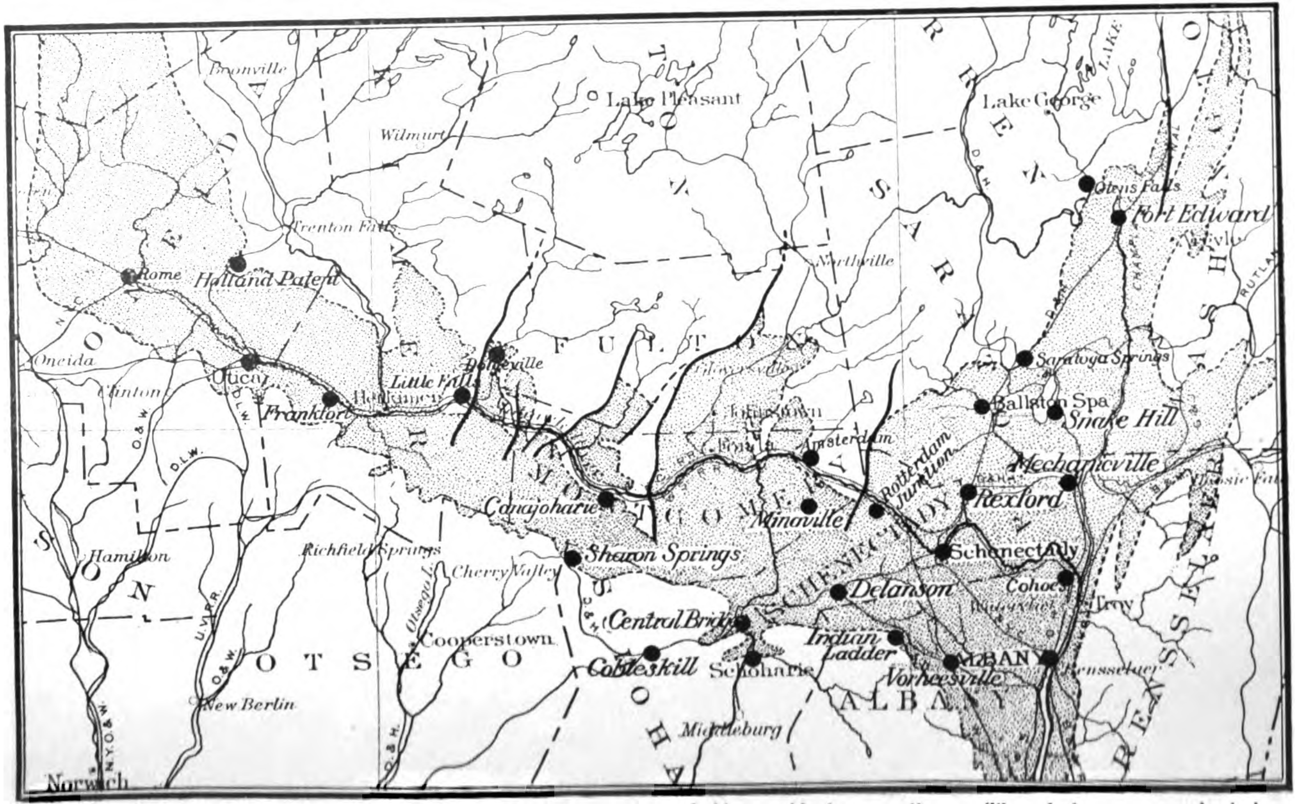

Figure 1 Locality map of the Shale belt in the Mohawk and Upper Hudson valleys. The shale area is shaded.

Canajoharie beds), the East Canada creek one from the Trenton through the transition beds into the lower Utica, while Moyers creek at Frankfort and the "Gulf" at Ilion give excellent sections through the Frankfort shale but fail to show its base. No continuous Utica section has been found in the neighborhood of Utica; the name according to Vanuxem is derived from the exposures in the Starch Factory creek (page 58, "a creek to the east of the city"), now largely within the city. The most important of these sections are here discussed in detail.

"UTICA" SHALE OF AUTHORS[1]

The belt of black "Utica" shale that follows the south side of the Mohawk valley is cut off by the Hoffman Ferry fault, as is well shown in the geologic map of the Amsterdam quadrangle by Prosser, Cumings and Fisher, to be replaced by an area of "Hudson River" or "Frankfort" beds that occupies nearly all Schenectady county and toward the east merges into the zone of folding. Just west of this fault, between Hoffman Ferry and Amsterdam, the south bank of the river is formed by cliffs of Little Falls dolomite and Trenton, above which, according to Prosser and Cumings, the contact of the Trenton and "Utica" is seen in several places, which have been visited by the writer.

In the *Swartztown creek section* (title 45, page 472; title 44, page 457) two feet of black partly noncalcareous, but mostly calcareous shale[2] is exposed overlying very fossiliferous Trenton. The contact in this section which is the first west of the Hoffman Ferry fault is disconformable and the surface of the Trenton irregular. The fossils are:

Corynoides calicularis *Nicholson*
Dicranograptus nicholsoni *var.* parvulus *nov.*
Diplogr. (Mesogr.) mohawkensis *nov.*

A mile farther west is a section opposite Cranesville (title 33, page 653) in which about 21 feet of basal Trenton, overlying the Amsterdam limestone (formerly Black River) with a little of the calcareous basal Utica shale, is shown. This again contained Corynoides calicularis and Diplogr. (Mesogr.) mohawkensis.

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[1] It will be shown in this paper that both the Utica shale and Frankfort shale of the lower Mohawk valley are of another, earlier, age than hitherto supposed. They will therefore, in distinction from the true Utica and Frankfort shales, be cited in quotation marks, until differently named.

[2] The "Utica" shale is described as calcareous in distinction from the Frankfort shale. The two have therefore been distinguished by Professor Prosser in the field by the use of the acid bottle.

An excellent section of the Trenton and basal "Utica" shale is exposed in *Morphy creek,* (title 33, page 654; title 44, page 460) halfway between Cranesville and Amsterdam and about one and one-half miles west of the preceding section. Here 5 feet. of Amsterdam limestone are overlain by 37 feet of Trenton limestone. The uppermost 27 feet are thin, irregular, dark blue, limestone layers with very black shale intercalations. These beds abound in Prasoporas, Trinucleus concentricus, Calymmene senaria, but contain no graptolites. The black calcareous Utica shale follows abruptly with profusely graptolitiferous beds, the species being:

Dicranograptus nicholsoni *var.* parvulus *nov.*
Diplogr. (Mesograptus) mohawkensis *nov.*
Diplogr. *cf.* putillus (*Hall*)
Rafinesquina alternata (*Emmons*) (small)
Leptobolus insignis *Hall*
Orthoceras *sp.*

It follows from this series of outcrops that the Lower Trenton or Prasopora zone at the eastern terminus of the continuous "Utica" belt of the Mohawk valley is separated by a disconformity indicating a small interval of nondeposition, from black calcareous shales characterized by Corynoides calicularis and a characteristic Diplograptus of the Mesograptus group. All three of these ravines reach the drift directly above the basal "Utica" beds and no satisfactory section of the upper "Utica" could be obtained. The latter is found along the south branch of the *Chuctenunda creek,* which empties opposite Amsterdam, and reaches back into the "Frankfort" shale hills, southwest of the village of Minaville where the transition from the "Utica" shale into the "Frankfort" shale is finely exposed in the ravines.

The contact between the Trenton and "Utica" is not shown in the section; the first outcrop is found at the falls of the creek, probably not more than 20 feet above the top of the Trenton. Here were found (Museum locality number 3758):

[1]	Diplograptus amplexicaulis	(cc)
	Diplograptus (Mesograptus) mohawkensis	(c)
	Lasiograptus eucharis	(r)
	Leptobolus insignis	(r)

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[1] cc = very common, c = common, r = rare, rr = very rare.

The next outcrop which furnishes fossils is in a small creek, coming in from the west, at the second bridge above 1, about 220 feet higher in the section. Here were found (Mus. loc. 3759):

2	Corynoides calicularis	(cc)
	Diplograptus foliaceus acutus	(cc)
	Triarthrus becki	(c)

A third fossiliferous outcrop was found along the main Chuctenunda creek one and three-fourths miles west by south, 70 feet above the preceding. This has furnished (Mus. loc. 3760):

3	Diplograptus (Mesogr.) mohawkensis	(cc)
	Lasiograptus eucharis (with colonies)	(cc)
	Leptobolus insignis	(c)
	Triarthrus becki	(r)
	Orthoceras *sp.*	(r)

There follow continuous outcrops for half a mile, all of which contain (Mus. loc. 3761):

4	Diplograptus (Mesogr.) mohawkensis	(cc)
	Lasiogr. eucharis	(cc)

At the end of this series of outcrops, about 30 feet above 3, (Mus. loc. 3762) Lasiograptus eucharis has become by far the prevailing fossil. There occur:

5	Diplograptus (Mesogr.) mohawkensis	(c)
	Lasiograptus eucharis (colonies)	(cc)
	Leptograptus insignis	(r)

A quarter of a mile farther up, beyond the fourth bridge (Mus. loc. 3763) the following fossils were obtained:

6	Diplograptus (Mesogr.) mohawkensis	(c)
	Lasiograptus eucharis	(cc)
	Leptobolus insignis	(r)
	Triarthrus becki	(c)

Three-quarters of a mile farther up, (Mus. loc. 3764), just below the village of Minaville and 300 feet above the first outcrop only

7 Lasiograptus eucharis, and
Leptobolus insignis

were collected. The next outcrop which is half a mile above Minaville is the base of the Minaville section, described by Cumings (title 44, page 463). Here in black, slabby calcareous shale were collected (Mus. loc. 3765):

8 Climacograptus *cf.* putillus
Lasiograptus eucharis
Leptobolus insignis

In a gully about one and two-fifths miles south by southwest of Minaville a continuous section 255 feet thick is exposed, which exhibits a complete transition from the typical lithologic character of the "Utica" to that of the "Frankfort." This section has been measured by Cumings and the following lithologic divisions distinguished:

K4 Mostly covered. Thin sandstone and arenaceous shales with a massive 2 foot layer at the base in the head of the glen. 120′ = 540′

K3 Black shales becoming olive to blackish at the top. These shales show a transition from the black calcareous shales of the "Utica" to the arenaceous, thin, crumbling shales of the "Hudson River" stage. 165′ = 420′

K2 Top consisting of slaty layers containing graptolites in abundance. Black, even shale. 90′ = 255′

K1 Mostly covered, but showing brown in weathering, slabby shale in the west bank of Chuctenunda creek, just above Minaville. 165′ = 165′

While K1 of this section has furnished the faunule cited under 8, the following division K2 was found to contain still, at least in its lower part (Mus. loc. 3770), specimens of

9 Diplogr. (Mesogr.) mohawkensis

Near the top (Mus. loc. 3769) a zone appears that is characterized by

10 Climacograptus spiniferus (cc)
Lasiograptus eucharis

K3 proved fossiliferous in one part (Mus. loc. 3768) where

11 Climacograptus spiniferus

occurs in great profusion.

The shales in this division, although still carbonaceous and very black like the "Utica" shale, do not any more react with HCl and are not calcareous.

K4, which consists prevailingly of thin sandstone and arenaceous shales of "Frankfort" aspect, still contains bands of black argillaceous shale, which usually yield graptolites on examination. At the base (120 feet from the top sandstone layer of the section) a band (Mus. loc. 3767) has furnished:

12	Climacograptus typicalis	(c)
	Lasiograptus eucharis	(cc)

The Lasiograptus eucharis occurs in an unusually large and broad mutation.

Another graptolite horizon was found but 22 feet from the top (Mus. loc. 3766). This contains:

13	Diplograptus (Amplexograptus) macer nov.	(c)

The graptolite that characterizes this fauna is an extremely narrow and long form, hitherto not observed at other horizons and therefore here distinguished by a new specific term (see Paleontologic notes, p. 82).

A survey of these localities as little suggests any sharp faunal boundaries as do the lithologic characters of the rocks. The rock is a black brownish weathering shale that strongly reacts with HCl. This character does not change until K3 (with horizon 11) is reached, when the black shale becomes wholly argillaceous. Nevertheless there is distinct though gradual change in the faunal aspect of the Utica shale as one passes upward. The basal beds at Morphy's and Swartztown creeks were found to be characterized by Corynoides calicularis and Diplograptus mohawkensis, two fossils which are wholly foreign to the Utica beds of the Utica section, or to the typical Utica beds. Corynoides calicularis is in the Chuctenunda section still abundantly found 220 feet above the base. Diplograptus mohawkensis remains the most common fossil, much longer, through 3 and 4, but in 5 it is replaced by Lasiograptus eucharis which remains the dominant graptolite to near the beginning of the transition beds, where it is somewhat abruptly displaced by Climacograptus spiniferus, (in 10) which hitherto had not been observed in the section. Then also Climacograptus typicalis appears and at the top a new species of Diplograptus. We may add that Lasiograptus eucharis, Climacograptus spiniferus and Climacograptus typicalis continue into and through the "Frankfort" shale in the lower Mohawk valley.

We can then distinguish three larger faunal zones, namely:

1 That of Diplograptus mohawkensis
Corynoides calicularis
2 That of Lasiograptus eucharis
3 That of Climacograptus spiniferus
Climacograptus typicalis
Diplograptus macer

All three of these zones are absent in the typical Utica section.

Another series of sections through the "Utica" shale, or at least its lower part, is afforded by the gulfs of Flat creek at Sprakers and of Canajoharie creek at Canajoharie. These places are about 20 miles west of the Chuctenunda sections and halfway between the latter and the typical Utica section of the Utica region.

The *Canajoharie creek and Sprakers sections* have been briefly described by Prosser and Cumings (title 33, page 638). They record at the former 53 + feet of Tribes Hill (Fucoidal) limestone, underlying 17 feet of thin bedded dark blue, very fossiliferous Trenton limestone with shaly partings. A distinct unconformity separates the two. About 300 feet of very black, bituminous slate referred to the lower "Utica" formation were found in the glen. The following fossils are cited from the Trenton:

1	Rafinesquina alternata (*Con.*), *Hall and Clarke*	(c)
2	Calymmene callicephala *Green* (?)	(r)
3	Orthis (Dalmanella) testudinaria *Dalm.*	(a)
4	Asaphus platycephalus *Stokes*	(c)
5	Monticulipora (Prasopora) lycoperdon *Say.*	(r)
6	Modiolopsis mytiloides *Hall* (?)	(rr)
7	Tellinomya levata *Hall*	(rr)
8	Zygospira recurvirostris (*Hall*), *Winch. and Schuch.*	(rr)
9	Plectambonites sericeus (*Sowb.*), *H. and C.*	(c)
10	Trinucleus concentricus *Eaton*	(r)
11	Atrypa (Protozyga) exigua *Hall*	(rr)
12	Ceraurus pleurexanthemus *Green* (?)	(rr)
13	Murchisonia bellicincta *Hall*	(rr)
14	Murchisonia gracilis *Hall* (?)	(rr)
15	Camarella *cf.* volborthi *Bill.*	(rr)
16	Stictopora *sp.*	(r)

and the following from the "Utica" which is stated to contain a larger number of fossils than has been found in the more eastern exposures:

1	Lingula quadrata (*Eich.*), *Hall* (?)	(c)
2	Plectambonites sericeus (*Sowb.*), *H. and C.*	(a)
3	Orthis (Dalmanella) testudinaria *Dalm.*	(c)

4	Triarthrus becki *Green*	(c)
5	Graptolites	(a)
6	Asaphus platycephalus *Stokes*	(r)
7	Tellinomya nuculiformis *Hall*	(r)
8	Pterinea trentonensis (*Conrad*)	(rr)
9	(?) Edmondia subtruncata (*Hall*)	(rr)
10	Endoceras proteiforme *Hall*	(c)
11	Raphistoma lenticulare (*Emmons*)	(r)
12	Trocholites ammonius *Conrad*	(r)
13	Rafinesquina alternata (*Con.*), *H. and C.*	(r)
14	Orthis (Dinorthis) pectinella *Emm., var.* semiovalis, *Hall*	(rr)
15	Crinoid segment	(rr)
16	Leptobolus insignis *Hall*	(r)
17	Lingula curta *Con.*	(a)
18	Monticulipora (Prasopora) lycoperdon *Say.*	(rr)
19	Bellerophon *sp.*	(rr)

With the exception of a bed of compact barren limestone at the base, which has an irregular surface and is separated by an unconformity from the overlying beds, the Trenton is composed of thin beds of limestone alternating with layers of shale of equal thickness, the whole having a distinctly transitional character like the beds designated as *Dolgeville beds* by Cushing. A limestone near the base is a shell-breccia and contains the brachiopods and trilobites cited by Prosser. This is followed by a thin bryozoan reef, from which Doctor Ulrich has identified:

Stictoporella *cf.* angularis *Ulrich*
S. exigua *Ulrich*
Phaenopora incipiens *Ulrich*
Pachydictya acuta (*Hall*)
P. pumila *Ulrich*
Eridotrypa mutabilis *var.* minor *Ulrich*

A small reef of broken shells swept up by a current, passes through the shaly Trenton limestone. This is especially rich in fossils and has furnished (*fide* Doctor Ulrich):

Corynotrypa inflata (*Hall*)
Atactoporella ? crassa *Ulrich*
Stomatotrypa ? *sp.*
Eridotrypa mutabilis *var.* minor *Ulrich*
Phylloporina reticulata (*Hall*)
Nematopora ovalis *Ulrich*
Arthroclema pulchellum ? *Billings*
Rhinidictya canadensis *Ulrich*
Pachydictya acuta (*Hall*)

P. pumila *Ulrich*
Stictoporella *cf.* angularis *Ulrich*
S. exigua *Ulrich*
Phaenopora incipiens *Ulrich*
Dalmanella futilis (*Sardeson*) *var.*
Rhynchotrema increbescens (*Hall*)
Eurychilina subradiata *Ulrich var.*
Calymmene senaria *Conrad*
Pterygometopus callicephalus (*Hall*)
Trinucleus concentricus (*Eaton*)

The shaly intercalations have afforded us:

Rafinesquina alternata (*Emmons*)	(c)
Leptobolus insignis *Hall*	(c)
Lingula curta (*Conrad*)	(c)
Dalmanites (Pterygometopus) callicephalus *Hall*	(r)
Diplograptus amplexicaulis *Hall*	(cc)
Diplograptus (Mesogr.) mohawkensis	(c)
Corynoides calicularis *Nicholson*	(r)
Ctenodonta *cf.* nuculiformis *Hall*	(r)
Ulrichia ? bivertex *Ulrich*	(c)
Primitiella unicornis *Ulrich*	(r)
Small ostracods of Primitia type	

It will be noted that the shaly intercalations of the Trenton limestone contain two of the most characteristic graptolites cited above from the basal " Utica " shale in the neighborhood of Amsterdam. Likewise it will be seen that also in the Canajoharie section these graptolites and all the other fossils observed in these shaly intercalations go up into the black " Utica " shales.

The fauna of both the limestone and the shaly intercalations is of earliest or basal Trenton age.

This belt of basal Trenton limestone with the underlying Amsterdam limestone can be traced by outcrops, rather widely separated through the faulting of the region, around the southeast side of the Adirondacks to Saratoga and Glens Falls. Since these beds are lower than any exposed at Trenton Falls, their reference to the Trenton is likely to lead to confusion and they should be recognized by a distinct name. For a time we have termed them the Jacksonburg limestone, but since the latter unit, recognized in New Jersey (title 59), also comprises beds of Amsterdam and Lowville age, it is not properly applicable to the limestone in question. As the latter is best exposed at Glens Falls with the underlying Amsterdam (Black Marble) limestone and overlying Canajoharie shale, we propose for it the term *Glens Falls limestone.*

The first 65 feet of the beds at Canajoharie (from the Glens Falls limestone to the lower falls) consist of calcareous shale with frequent small limestone seams near the base. The shale is deep black, calcareous, hard and splintery, brownish weathering. It contains:

Diplograptus amplexicaulis *Hall*	(cc)
Leptobolus insignis *Hall*	(c)
Schizocrania filosa *Hall*	(c)
Lingula curta *Conrad*	(c)
Calymmene senaria *Conrad var.*	(c)
Ctenodonta nuculiformis ? *Hall*	(r)
Primitiella unicornis *Ulrich*	(r)

An extremely rich zone was observed in the cliff directly above the falls (65–120 feet from base). This has furnished:

Diplograptus amplexicaulis (*Hall*)	(cc)
Corynoides calicularis *Nicholson*	(c)
Diplograptus (Mesograptus) putillus *Hall*	(r)
Lasiograptus eucharis (*Hall*)	(c)
Sponge spicules	
Spatiopora *sp.*	
Leptobolus insignis *Hall*	(c)
Lingula curta *Conrad*	(r)
Dalmanella testudinaria (*Dalman*)	(c)
Rafinesquina alternata (*Emmons*) small	(c)
Plectambonites sericeus (*Sowb.*) H. & C.	(c)
Hyolithes pinniformis *nov.*	(c)
Prolobella ? trentonensis (*Hall*)	(c)
Pterinea insueta[1] (*Emmons*)	(r)
Ctenodonta *cf.* nuculiformis (*Hall*)	(c)
Clidophorus *sp.*	(c)
Ctenodonta *sp. nov.* large	(rr)
Whiteavesia *sp.*	
Clathrospira subconica (*Hall*)	(c)
Liospira *cf.* rotuloides (*Hall*)	(c)
Orthoceras *sp.*	(r)
Calymmene senaria (*Conrad*)	(cc)
Lepidocoleus jamesi (*Hall & Whitfield*)	(c)
Turrilepas filosus *Ruedemann*	(r)
Ulrichia ? bivertex *Ulrich*	(c)
Primitiella unicornis *Ulrich*	(cc)
Minute Primitias	

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[1] This last species, described by Hall in Paleontology New York, 1:291, is known only from this locality. Hall states of it: "This species occurs in the lower black shale, or Utica slate, at Canajoharie, and is known in the higher part of the group."

A third series of outcrops begins with a cliff on the north side of the creek, about 115 feet above the base and reaches to 150 feet. The shales of this are lithologically identical with the underlying rock. These beds contain:

Cyathodictya ? tubularis *nov.*	(cc)
Glossograptus quadrimucronatus *mut.* cornutus *Rued.*	(c)
Diplograptus (Mesograptus) putillus *Hall*	(cc)
Lasiograptus eucharis (*Hall*)	(r)
Spatiopora *sp.*	(r)
Leptobolus insignis *Hall*	(c)
Lingula curta *Hall*	(c)
Rafinesquina alternata (*Emmons*)	(r)
Orthoceras *sp.*	(r)
Ulrichia ? bivertex *Ulrich*	(c)
Primitiella unicornis *Ulrich*	(c)

The most novel element of this association is Glossograptus quadrimucronatus mut. cornutus. This characteristic form has before been known to us only from the Rural Cemetery beds near Albany which we had referred in Bulletin 42 to the Utica. It is there associated with Diplogr. (Mesogr.) putillus and Corynoides calicularis. It is safe to infer on the strength of this form that the Rural Cemetery beds and this portion of the Canajoharie beds belong to the same horizon. Some layers are profusely covered with the problematicum termed here Cyathodictya? tubularis. This fossil is described in the paleontologic notes at the end of this paper.

The fourth series of beds is exposed in a cliff reaching from 150 feet above the base to about 270 feet. These beds contain:

Cyathodictya ? tubularis *nov.*	(c)
Corynoides calicularis *Nicholson*	(cc)
Glossogr. quadrimucronatus *mut.* cornutus *Rued.*	(cc)
Diplograptus (Mesogr.) putillus *Hall*	(cc)
Prasopora simulatrix *Ulrich*	(c)
Lingula curta *Hall*	(c)
Triarthrus becki *Green*	(cc)
Calymmene senaria *Conrad*	(r)
Ulrichia ? bivertex *Ulrich*	(c)

Triarthrus becki, which before had not been noticed, appears in this last division about 40 feet from the base in great numbers. Glossograptus quadrimucronatus mut. cornutus and Corynoides calicularis were found near the top of this last cliff with which end the outcrops in the Canajoharie gulf.

A series of exposures which to a large degree is complementary to the one just described is afforded by the *Flat creek ravine at Sprakers,* two and one-half miles east of the Canajoharie ravine.

The Glens Falls limestone is finely exposed in this section. It is 17 feet thick and consists of thin layers of very fossiliferous limestone with shale intercalations near the top and a two-inch conglomeritic layer at the base, separating it from the Tribes Hill (Fucoidal) limestone. The limestone beds exhibit large ripple marks, small piles of current-swept pebbles and other signs of shallow water conditions. Besides the fossils noted from the Canajoharie beds, Eurychilina subradiata was also collected.

The "Utica" shale comes in, notwithstanding the shaly intercalations of the upper Glens Falls beds abruptly as a black shale formation. It contains directly at the base:

Diplograptus amplexicaulis (*Hall*)	(cc)
Ctenodonta *cf.* nuculiformis (*Hall*)	(c)

1 Ten feet above the base abundant Diplograptus (Mesogr.) putillus and ostracods (Ulrichia ? bivertex, Primitiella unicornis, Primitia) were observed, which continued through 20 feet, where also layers with great numbers of Leptobolus insignis and limestone bands filled with Dalmanella testudinaria were observed.

2 The beds from 30–60 feet above the base furnished:

Diplograptus amplexicaulis	(cc)
Cyathodictya ? tubularis	(cc)
Leptobolus insignis	(cc)
Ctenodonta *cf.* nuculiformis	(c)

3 From 60 feet above base upward there were observed besides:

Diplograptus amplexicaulis	(cc)
Orthoceras *sp.*	
Lingula curta	(c)

4 75 feet above base besides Diplograptus amplexicaulis and the ostracods, specimens of Clathrospira subconica (Hall) were found.

5 From 110–20 feet Calymmene senaria occurs in great abundance and from 125–30 feet fragments of Isotelus and Prasoporas fill the beds. Also at about 135 feet above the

base is a bed of abundant small Prasoporas. It is important that this Prasopora, forming here an horizon, has been recognized by Doctor Ulrich as the lower Trenton Prasopora simulatrix.

6 Directly above this bed Triarthrus becki begins to be observed in considerable numbers and it continues to be the common fossil through a considerable thickness.

7 From 160–80 feet Triarthrus becki and Corynoides calicularis are the dominant fossils, while

8 At 210 feet above base Lasiograptus eucharis appears in great numbers and typical expression. It is associated with:

Triarthrus becki, and
Lingula curta

This association was observed to the top (230 feet) approaching which were found:

Sphenothallus angustifolius *Hall*[1]	(cc)
Dalmanella testudinaria (*Dalm.*)	(cc)
Schizocrania filosa *Hall* (in large specimens)	(c)
Trocholites ammonius *Hall*	(c)
Orthoceras *sp.*	(c)

This congeries is typically that observed in the lower "Utica" shale in the East Canada creek section at Dolgeville and it is notable that also the lithic character of the light drab weathering, blocky, polygonal breaking, thick-bedded mud-shale is the same as that prevailing in much of the lower parts of the shale at Dolgeville. We consider it therefore probable that the top of this section is equivalent to the lower part of the Dolgeville "Utica."

In a new road cut between Flat creek and Canajoharie about 340 feet above base of "Utica," hard and thin-bedded black shale was found, containing:

Climacograptus spiniferus (filling one bed)	(cc)
Leptobolus insignis	(c)
Triarthrus becki	(c)

Another road cut 40 feet higher and to the north of the former furnished again abundant:

Climacograptus spiniferus	(c)
Diplograptus vespertinus[2]	(cc)

This shale is very strikingly dark and light banded.

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[1] *See* Paleontologic notes, p. 74.

[2] *See* Paleontologic notes, p. 83.

The heavy drift to the south has buried the "Utica" beds as far as the "Frankfort" beds at the base of the Helderberg escarpment.

If we combine the observations of Canajoharie and Flat creeks, we obtain the following groups of faunules, indicative of larger zones:

1 Zone of Diplograptus amplexicaulis, Corynoides calicularis, ostracods, lamellibranchs (notably Pterinea (Prolobella?) trentonensis and insueta, etc.).

2 Zone of Glossogr. quadrimucronatus cornutus, Corynoides calicularis, the ostracods, Cyathodictya, Triarthrus becki.

3 Zone of Lasiogr. eucharis, Lingula curta, Schizocrania filosa, Trocholites ammonius, Triarthrus becki.

4 Zone of Climacogr. spiniferus, Diplogr. vespertinus, Lasiogr. eucharis, Triarthrus becki

The first two zones have never, in our earlier work, been observed in the Dolgeville section, while the base of that latter section has furnished us a faunule identical with that of number 3. To be sure of the absence of the lower two zones in the Utica region, we have carefully searched the basal sections of the Utica at Dolgeville and Jacksonburgh, three miles west of Little Falls, where Cushing's map shows an exposure of the contact of Dolgeville (transition) beds and Utica shale; along the Starch Factory creek at Utica; and the exposure between Holland Patent and South Trenton, recorded by Miller. In none of these localities were any traces of the first two zones of the Canajoharie section found. On Nine Mile creek near South Trenton, where the contact of the Trenton and true Utica is exposed, Climacograptus typicalis is the dominant and characteristic graptolite of the basal Utica. This typical Utica graptolite occurs there in immense multitudes. It is associated with:

Mastigograptus simplex (*Walcott*)
M. tenuiramosus (*Walcott*)
Pleurograptus linearis (*Carruthers*)
Leptograptus annectans (*Walcott*)
Dicranograptus nicholsoni *Hopkinson*
Glossograptus quadrimucronatus (*Hall*), short, long spined variety
Cyathophycus reticulatus *Walcott*

This is the *characteristic fauna of the base of the typical Utica.* It is the Mastigograptus fauna of Schuchert (1910, p. 529). Lasiogr. eucharis appears in great numbers nearby (at Floyd and Marcy) and a little higher up.

In the Dolgeville and Jacksonburgh sections which lie halfway between Utica and Canajoharie, the base of the "Utica" shale (above the Dolgeville transition beds) shows no trace yet of the Canajoharie faunule, but contains:

Glossograptus quadrimucronatus
Climacograptus typicalis
Lasiograptus eucharis
Lingula curta
Schizocrania filosa

The dominant Climacograptus typicalis of the true Utica is found but sparingly, and Leptograptus annectans, Pleurograptus linearis, Dicranograptus nicholsoni and the Mastigograpti are not observed at all in the bed. It is therefore probable that the basal "Utica" at Dolgeville-Jacksonburgh and that at Utica do not represent the same horizons, and if so, the former is probably older than the latter.

From the assemblage of the facts here presented, we infer that at Canajoharie the two lower zones surely and the others most probably lie below the base of the true Utica and correspond in age to some part of the Trenton. For this older black shale of the Mohawk valley we propose the term *Canajoharie shale.* This stage is characterized by the following species:

Corynoides calicularis
Diplograptus amplexicaulis
Diplogr. (Mesogr.) mohawkensis
Glossograptus quadrimucronatus *var.* cornutus
Pterinea (Prolobella) trentonensis
P. insueta
Ulrichia? bivertex
Primitiella unicornis

All these are unknown to us from the Utica shale. A number of forms as Lasiogr. eucharis, Diplogr. putillus, Triarthrus becki, appear in the Canajoharie beds rarely, but become dominant forms in the Utica shale, and others, as the shale brachiopods Leptobolus insignis and Lingula curta, are equally common to both. The true Climacograptus typicalis has not been seen in the Canajoharie beds, but is a most characteristic and common graptolite of the Utica beds.

A peculiar feature which we are at present unable to explain is the very frequent occurrence of Diplogr. (Mesogr.) mohawkensis in the Canajoharie beds in the Amsterdam sections and its apparent absence in the Canajoharie sections. Since it is not restricted there to the basal beds only, it can not be assumed that it represents still a lower horizon not represented at Canajoharie.

If the Canajoharie shale is older than the true Utica, it corresponds in age to some part of the Trenton. The question then arises, How much of the Trenton does it represent? The fossils of the underlying Trenton and transition shale at Canajoharie (see page 21) are those of the basal Trenton only, and this alone is represented by limestone in the lower Mohawk valley,[1] where it rests on the Amsterdam limestone. The lower Trenton, which is characterized by the Prasopora simulatrix zone and its base by the fauna of the Nematopora beds, is apparently at Canajoharie merged already in the Canajoharie formation, as the occurrence of a horizon with Prasopora simulatrix, rather high up in the Canajoharie beds in Flat Gulf (page 26) and the evidence of the bryozoan reefs at the base of the Canajoharie would indicate. The Canajoharie beds correspond therefore to at least the lower Trenton. What proportion, if any, of the middle Trenton is included can not be determined with the data at hand. The typical Canajoharie fauna at Canajoharie indicates as old Trenton as the oldest in the Trenton Falls section. Possibly it contains only lower Trenton but probably it belongs in large part between the lower and middle Trenton.

The true Utica is, from present evidence, entirely absent in the lower Mohawk region. We infer this from the faunas of the Canajoharie shale indicating Trenton age and further from the facts that these black shales pass gradually (as in the Minaville section) into the so called "Frankfort" or "Hudson River" shales and sandstones of the lower Mohawk valley and that these latter have proved to be of an age older than upper Trenton (see Schenectady formation, page 37).

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[1] This conclusion had also been reached by Cumings (title 44, p. 466).

The writer has before cited faunules from the Hudson valley which contain the characteristic elements of the Canajoharie beds. The most important of these is that from the Rural Cemetery of Albany, whence Glossogr. quadrimucronatus mut. cornutus was described. It is there associated with

Mastigograptus circinalis *Rued.*
Corynoides calicularis *Nicholson*
Lasiograptus eucharis (*Hall*)
Diplogr. putillus (*Hall*)
Eopolychaetus albaniensis *Rued.*
Pontobdellopsis cometa *Rued.*
Leptobolus insignis *Hall*
Schizambon ? fissus *var.* canadensis *Ami*
Hormotoma *cf.* gracilis (*Hall*)[1]

This is one of the various upper subzones of the " Hudson River shales " which in the former publications (op. cit. page 36) we have referred to as an eastern development, characteristic of the Appalachian trough, of the Utica shale.

The belt of Canajoharie beds in the lower Mohawk valley is abruptly cut off by the Hoffmans Ferry fault which, since the eastern side has dropped, has buried all lower beds east of the fault, under a belt of " Frankfort " shales and sandstones extending from the town of Galway in the north across the Mohawk river to the foot of the Helderbergs. It becomes evident, however, from the facts cited above, that the Canajoharie beds reappear from under this thick mass of overlying " Frankfort " shales on the east, along the Hudson, through the Taconic-Green Mountain folding and they strike there according to this folding to the north-northeast, as indicated by the outcrops at the Rural cemetery and at Cohoes.

The stations which we had cited in Bulletin 42 as representing the Utica shale and forming a belt that passes through Albany, are now mostly to be considered as Canajoharie beds, the same as the occurrence at the Rural cemetery, and the few remaining like that at Black creek, Voorheesville and the Vly at Voorheesville (title 47, pages 531–33) are black shale zones intercalated in sandstones and correspond to the " Frankfort " rocks about Schenectady. We must infer from these facts that typical Utica is not represented in the Hudson River region but that the Canajoharie shale is directly followed by the " Frankfort " (Schenectady) beds.

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[1] *See* title 47, p. 528; title 60, p. 37.

This is, among others, suggested by an outcrop at Crescent, at the last bend of the Mohawk. At the latter place an anticline brings to the surface (thereby causing the rapids in the river) about 50 feet of "bluestone" (a calcareous sandstone) of the type characteristic of the "Frankfort" (Schenectady) beds, in beds 2–3 feet thick with intercalations of black shale. The latter, however, do not furnish the "Frankfort" faunule, noted in a later chapter, but

Corynoides calicularis *Nicholson*
Cf. Azygograptus ? simplex *Rued.*
Diplograptus putillus *Hall*
Climacograptus bicornis *Hall*
Diplograptus *cf.* angustifolius *Hall*
Leptograptus annectans *Walcott* (narrow form)

This congeries of forms contains on one hand the Corynoides on account of which we refer the beds to the Canajoharie formation, a reference which is supported by the close position of the outcrops to the belt of Canajoharie beds at the mouth of the Mohawk. It also contains Leptograptus annectans, a species that to our knowledge has been found hitherto only in the basal Utica beds in the neighborhood of Trenton, N. Y., and in the true Utica beds of Cincinnati (title 61, page 265) but the form representing this species at Crescent is not strictly the same as the typical Holland Patent type. The lithologic features of this interesting outcrop also indicate the fact that in the east, the upper portion of the Canajoharie formation may assume the lithologic character of the "Frankfort" (Schenectady) beds, a fact that would argue for a direct succession of the two formations in this region.

While the Canajoharie shale is eastward in the Mohawk valley cut off by the Hoffman's Fault, we have found it to reappear north of Schenectady along Alplaus creek and thence the black shales can be traced past Ballston Spa, Saratoga and along the edge of the Precambric to Glens Falls, where they are again cut out by faults. The locality on Alplaus[1] creek has afforded:

Corynoides calicularis
Glossograptus quadrimucronatus *mut.* cornutus
Lasiograptus eucharis
Leptobolus insignis
Orthoceras hudsonicum *nov.*[2]

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[1] A curious distortion of the old German locality name "Aalplatz," eel-place.

[2] This species retains in pyritized condition the protoconch and nepionic portion of the shell. See note, p. 113.

There can be no doubt of the Canajoharie age of the rock of this outcrop, and yet it is only two miles due north of the " Frankfort " outcrops of Rexford Flats, leaving but a narrow strip for a possible belt of intervening Utica shale; and considering the very slight southwest dip of the rocks also but little room for any thickness of the Utica shale.

Fine exposures of these Canajoharie shales were observed about Ballston Spa, especially along Kayaderosseras creek. Here occur:

Dicranograptus nicholsoni	(rr)
Glossograptus quadrimucronatus (in some beds large and typical)	(r)
Climacograptus spiniferus	(cc)
Lasiograptus eucharis	(r)

A similar faunule was observed on the Glowegee, northwest of Ballston Spa, while the single outcrop at Saratoga (Carlsbad Spring) contains:

Climacograptus spiniferus
C. mohawkensis
Lasiograptus eucharis
Leptobolus insignis

An excellent outcrop of the Canajoharie beds between Saratoga and Glens Falls is that at the falls of the Snook kill at Gansevoort, where occur:

Glossograptus quadrimucronatus *mut.* cornutus
Diplograptus mohawkensis
Lasiograptus eucharis

Very important exposures were found above and below Glens Falls. Those above are near the feeder dam, one to two miles southwest of the city and contain:

Corynoides calicularis
Diplograptus amplexicaulis
Glossograptus quadrimucronatus
Leptobolus insignis
Pontobdellopsis cometa
Orthoceras *nov. cf.* amplicameratum
Triarthrus becki

Between Glens Falls and Hudson Falls (formerly Sandy Hill) the contact between these shales and the basal Trenton limestone can be observed — or rather could be observed — the feeder dam between the paper mills and the mill races on both sides having rendered inaccessible the contact exposed in the river bed. This contact was recorded by Mather (title 2, p. 394) as follows:

> At a little distance below the ferry on the Saratoga shore, at and near the sawmill, the junction of the slate and Trenton limestone, and the gradation of one into the other by interstratification, with the numerous and beautiful fossils, which are intermingled near their junction, can easily be examined when the river is low. The trilobite, the Nuttainia concentrica of Eaton [Trinucleus concentricus (Eaton)], is extremely abundant, and on one specimen of a thin band of limestone six inches square, from the slate, were no less than ten of these trilobites, some of which were entire, and one of the Triarthrus becki.

While these transition beds can not be seen any more in place, the construction of the mill race for the Fenimore Paper Mill opposite Hudson Falls has brought to light a great quantity of the transitional rock which has been dumped along the river bank just above the mill. It consists of dirty grayish-brown limestone with black shale seams. The limestone is very fossiliferous; the following fossils have been noted:

Mesotrypa quebecensis (*Ami*)
Schizocrania filosa *Hall*
Dalmanella testudinaria (*Dalman*)
Plectambonites sericeus (*Sow.*)
Triarthrus becki *Green*
Trinucleus concentricus (*Eaton*)
Isotelus fragments

The shales at the falls contain:

Corynoides gracilis *Hopkinson*
Diplograptus amplexicaulis *Hall*
Climacograptus spiniferus ***Ruedemann***
Lasiograptus eucharis (*Hall*)
Trocholites ammonius *Conrad*

These shales can thence be followed about two miles through a fine gorge to the falls at Fort Edward, where there are found:

Corynoides calicularis ***Nicholson***
Diplograptus *cf.* euglyphus *Lapworth*
Trematis terminalis (*Conrad*) ?
Orthoceras arcuolineatum ***nov.***

From Fort Edward this belt of shale can be followed down the Hudson river for several miles. Occasionally, as in an outcrop two miles south of the mouth of the Snook kill, limestone bands one to two inches thick appear, which are entirely composed of brachiopod, trilobite and crinoid fragments, but collecting will not furnish anything but the common brachiopods Dalmanella testudinaria, Rafinesquina, Plectambonites sericeus and the trilobite Trinucleus concentricus. The surrounding shales contain: Corynoides calicularis, Climacograptus spiniferus, C. putillus, Lasiograptus eucharis. The last mentioned form was also observed to fill a band of black shale about three miles up the Snook kill, where it is associated with Trocholites ammonius.

The following inferences in regard to this belt of black shales in Saratoga county seem of importance for the present inquiry:

1 These shales which have hitherto been considered as good typical Utica shales, are in their lithologic aspect like the latter but lack the strong calcareous admixture and for that reason rarely effervesce with acid. But, as we shall show later, they are lithologically quite distinct from the belt of Snake Hill beds, which adjoin them to the east, the latter containing not only numerous intercalations of grit and sandstone beds, as at Snake hill, but being also thinner bedded, more fissile, more argillaceous and less carbonaceous, approaching in their character the Frankfort shale.

2 The fauna of these shales is that of the Canajoharie beds of the Mohawk valley, as shown by the occurrence of and dominance of Corynoides calicularis, Diplograptus amplexicaulis, Glossograptus quadrimucronatus mut. cornutus, Lasiograptus eucharis.

3 These shales rest also in this belt on the basal Trenton (Glens Falls) limestone. This relation was observed, as above stated, at Hudson Falls. It may also be inferred from the outcrops on the Glowegee west of Saratoga, which lie but a short distance south and in the dip of the belt of basal Trenton (Glens Falls) limestone passing west of Saratoga through Rowland's mill and Rock City Falls.

FRANKFORT SHALE

The type locality of the Frankfort beds is the gorge of Moyer creek at Frankfort, about nine miles southeast of Utica. A parallel series of fine outcrops is furnished by Steels creek, only two miles away, in the so-called Ilion gulf.

Investigations of these two sections have shown that both lack the base or the contact with the Utica beds. A comparison with the sections of Starch Factory and Ferguson creeks near Utica indicates that the Frankfort and Ilion sections begin closely above the Utica shale. This is also evident from the fact that on the other side of the Frankfort section only two miles to the east, the Utica shale is still exposed on Fulmer creek south of the village of Mohawk. The strike of the shale in the latter outcrop will carry it to very near the base of the Frankfort and Ilion sections.

We found in the rock section at Frankfort which by aneroid is 305 feet thick,[1] four bands of shale containing fossils. The first of these was collected 15 feet above the base of the section at the foot of a cliff 60–70 feet high.

1 Climacograptus typicalis *Hall*
Lingula fragment
Leptobolus insignis *Hall*
Camarotoechia *sp.*
Orthoceras *sp.*
Triarthrus becki *Green*
Trinucleus concentricus (*Eaton*)

The next fossiliferous band was found about 85 feet above the base at the second bridge over the creek. Here were obtained:

2 Climacograptus typicalis *Hall* (large specimens)
Prasopora *sp.* (minute colony)
Leptobolus insignis *Hall*
Dalmanella testudinaria (*Dalman*) *mut.*
Rhynchotrema inaequivalve (*Castelnau*)
Modiolopsis *sp.* (fragment)
Orthoceras *sp.* (septum)
Triarthrus becki *Green*
Trinucleus concentricus (*Eaton*)

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[1] Since these beds dip toward the southwest with an angle that locally is 5°, but in general not more than 2°, it is obvious that this figure is too small. Cushing (1905, p. 36) has determined the surface of the Beekmantown to fall from Middleville to Ilion at a rate of somewhat over 100 feet a mile, stating that the line of greatest dip runs somewhat more to the westward of this direction. This line of greatest dip would then come near the direction of the Frankfort section and since a fall of 100° in a mile corresponds to but 1° of dip, while the average dip in the Frankfort section appears to be perhaps twice as much, it is safe to assume that at least 200 feet should be added, but probably a thickness of between 200 and 370 feet, the latter figure corresponding to a dip of 2°.

At about the same level is the black shale at the base of the Ilion section (230 feet below the Oneida conglomerate), which has furnished:

Climacograptus typicalis *Hall*
Leptobolus insignis *Hall*
Dalmanella testudinaria (*Dalman*) *mut.* (small)
Dinorthis pectinella (*Emmons*)
Rhynchotrema inaequivalve (*Castelnau*)
Cf. Serpulites longissimus *Murchison*
Triarthrus becki *Green*

No fossils were observed until about 240 feet above the base, where occur:

3 Leptobolus insignis *Hall*
Orthoceras *sp.*

The last fossiliferous shales were found directly below the top (280-305 feet). They furnished:

Climacograptus typicalis *Hall* (c)
Orbiculoidea tenuistriata *Ulrich* (*fide Ulrich*)
Leptobolus insignis *Hall*
Orthoceras (fragment)
Triarthrus becki *Green*

Of these fossils the Orbiculoidea tenuistriata and the Triarthrus becki were found in the shale directly below the Oneida conglomerate.

It is obvious that these small faunules lack the essential elements of the Lorraine fauna and do not appear to consist of more than an impoverished Utica fauna. We see the strongest evidence of the close faunistic relation between the Utica and Frankfort periods in the uninterrupted persistence of Climacograptus typicalis through the whole of the Frankfort shales.

As it will be shown in the next chapter that the beds in the lower and probably middle Mohawk valley which have been hitherto referred to the Frankfort are of much older age, the Frankfort formation disappearing eastward by overlap and the relations of the typical Frankfort beds of the Frankfort section westward and northward have not yet been studied in detail, it becomes necessary to restrict for the present the term Frankfort shale to the formation as exposed in the Utica region. The formation thus restricted has its basal limit defined by the top of the true Utica, while the upper boundary, which in the Utica region is formed by the Oneida conglomerate, is not yet well defined in regard to the Pulaski formation, the question being to which of the two the shale with Trinucleus northwest of Utica is to be referred. Doctor Ulrich writes that he is inclined to place it with the Frankfort and to confine the Pulaski to the overlying even more fossiliferous arenaceous limestone and shale shown at Pulaski and in the upper part of the Lorraine gorge.

The problem of the correlation of the Frankfort formation, thus restricted and defined, with the strata of Ohio has been discussed very fully by Doctor Ulrich and the author. Doctor Ulrich recognizes in the Frankfort s. str. the two middle divisions of the Eden shale at Cincinnati, but he is convinced that it also includes the upper Eden. The Eden, as used by Doctor Ulrich for a long time, is confined to beds beginning at the top of the true Utica and extending upward to the base of the Maysville. But as originally defined the Eden included all the shales to the top of the underlying Point Pleasant Trenton limestone in the Ohio valley; hence it included also the thinning western representative of the true Utica. For this reason Doctor Ulrich has proposed to use the term Eden for a group comprising the Utica and Frankfort (title 69, plate 27). The Eden in Ohio is followed by the Maysville, which in New York is represented by the Pulaski formation and Oswego sandstone. The Lorraine, we infer from the above-cited chart, is retained as a local or New York term only to comprise the Frankfort and Pulaski formations.

SCHENECTADY FORMATION

As the black shale belt that follows the Mohawk river from Utica to near its mouth has always been considered as being of Utica age, but has been found to change in age from Utica to lower Trenton in descending the river, thus the parallel and coextensive belt of overlying, more argillaceous, olive gray shales has been quite naturally identified with the Frankfort shale by all authors, the present included, since these beds apparently form a continuous belt, just as the underlying black shale does. When we discovered in the great thickness of " Frankfort " beds in Schenectady and Schoharie counties the eurypterid fauna associated with a considerable number (see page 42) of graptolites, brachiopods, mollusks and trilobites, different from those of the Frankfort shale, we distinguished there several thousand feet of sandstones and shales as the " Schenectady facies " of the Frankfort formation. Closer investigation of the faunas, with the assistance of Doctor

Ulrich, has led to the conclusion that they are at least as old as upper Trenton and probably belong mainly between the middle and upper Trenton. We therefore propose to distinguish this formation as a separate unit under the term *Schenectady formation,* its type exposures being at the Dettbarn quarries at Schenectady and at Aqueduct and Rexford Flats near Schenectady.

The conclusion of an age older than the Utica for the Schenectady formation is supported by, or at once explains, the close connection by transitional beds of the Canajoharie beds (which are of lower to middle Trenton age) and these " Frankfort " beds of the lower Mohawk valley, as shown in the section about Minaville and along the Schoharie creek.

The Utica shale, if it continued down the Mohawk valley, would have to be found above the Schenectady beds. This inference is supported by the fact that the latter are overlain by the Indian Ladder shales (see page 50) which correspond in age to the Southgate of the Eden group and are but little younger than the true Utica.

If one follows the foot of the Helderberg escarpment from the typical exposures of the Frankfort shale down the Mohawk valley, one meets but few rather widely separated outcrops of the barren, olive gray Frankfort shales until one reaches the lower Mohawk valley region, where the rather abrupt widening of the belt and the thickening of the formation together with the appearance of much calcareous sandstone (bluestone) combine to change greatly the aspect of the " Frankfort " beds. The exact contact plane between the Frankfort shales that thin out eastward and the Schenectady beds that rapidly diminish westward, has not yet been established and may be entirely buried in the deep drift plateau between the foot of the Helderbergs and the Utica and Canajoharie exposures in the lower reaches of the southern affluents of the Mohawk.

The *thickness* of the Schenectady formation must be very great. Cumings (title 44, page 466) has already found in the hill back of Rotterdam a thickness of 1200 feet at least for the " Hudson River " beds, for the top of the formation is not there reached. That the thickness of the Schenectady formation is still considerably more, is proven by the Altamont well-boring. In that well, the drill started 595 feet below the top of the Indian Ladder beds and passed through 2880 feet of sandstone and shales before reaching the Trenton limestone. The shale formations have hence a total thickness of 3475 feet there. The lowest 1200 feet of this may be

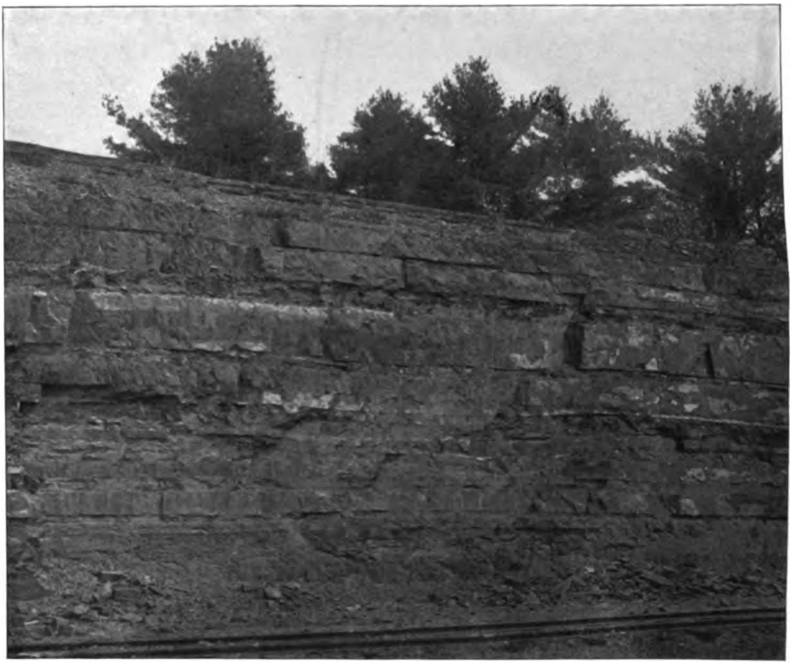

Figure 2 Schenectady beds at Aqueduct, showing the alternating beds of sandstone ("bluestone") and shale

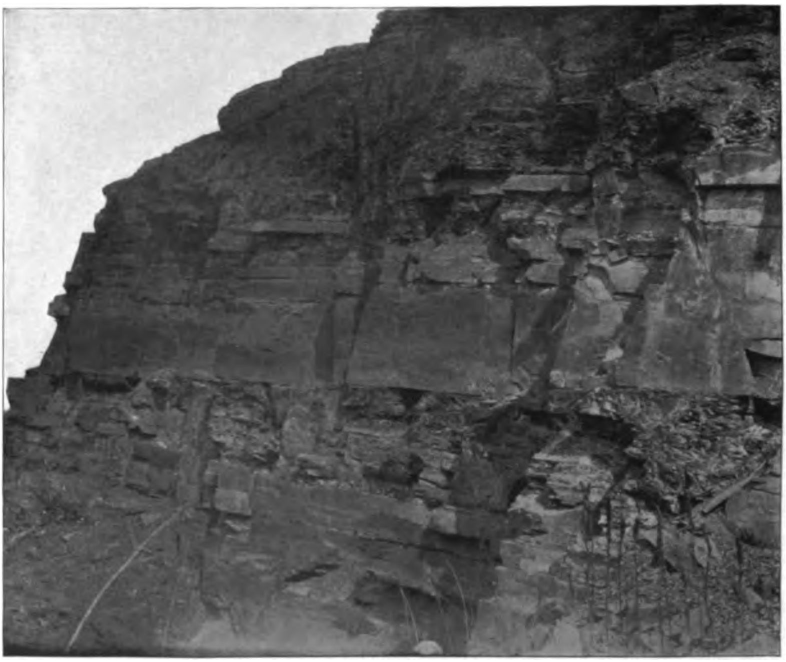

Figure 3 Nearer view of same quarry face to show irregular deposition of beds

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attributed to the Canajoharie shale, since Cumings (op. cit. page 466) measured 950 to 1260 feet of black shales in the lower Mohawk region and 300 feet at least at the top belong to the Indian Ladder beds, a formation that follows the Schenectady beds in this region and will be discussed later (see page 50). There remain then 1800–2000 feet of Schenectady beds, since we properly assume that neither the Normanskill nor the Snake Hill beds reach as far west as Altamont. The Normanskill and Snake Hill beds extend considerably farther west than their original basin of deposition (see diagram, page 69) through extensive overthrusting which, however, has not reached the meridian of Altamont where the beds are undisturbed.

There are other lines of evidence which indicate a similar great thickness for the Schenectady shale and sandstone. One of these is the width of the belt of shales from Amsterdam to the Helderbergs which at the rate of 140 feet dip in a mile, observed for the Glens Falls limestone, corresponds to a thickness of 1925 feet of shale (13.75 miles by 140), to which must be added 900 feet representing the difference in height of the base of the shales at the north and their top in the south, subtracting from this 2825 feet again the 1140 feet found in that meridian for the Canajoharie shale, we obtain approximately 1700 feet for the Schenectady beds, the Indian Ladder beds having disappeared along the Schoharie creek section. The dips along the line Aqueduct to Schoharie, which are mostly southwest to west and amount to 1°–2°, frequently as much as 5°, as at Aqueduct, would also indicate a thickness of more than 2000 feet (2681 feet at 1° dip).

The cause of the astonishing thickness of the Schenectady shales is to be sought in their deposition in a basin, namely, the sinking foreland in front of the rising Green Mountain folds to the east; which basin was rapidly being filled with sediments. The shallow water origin of most of the shales and sandstones of the Schenectady beds is proven by the sun-cracks found in the thinner sandstones (as at the Bozen kill), the frequent layers of mud pebble beds,[1] cross striation with plunge structure, very rapid change of thickness of beds and other features.

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[1] These mud pebble layers occur mostly on top of the sandstone beds, when the latter are followed by argillaceous shales, indicating that the first clay deposits were rolled about by the waves upon the sand and formed into mud balls.

The rocks of the Schenectady formation contain a much greater amount of sandstone beds than the other shale formations of New York. Much of this sandstone occurs in thick banks, is somewhat calcareous and much quarried as "bluestone." The hundredfold alternation of these sandstone beds with the shales which persists to a more or less extent throughout the whole formation is the most notable lithic character of the eastern development. Numerous sections which show these endless alternations of sandstone which, on account of its often coarse nature, is cited as grit, with slate, have already been published by Mather in the First District Report (pages 375–79), from the lower Mohawk and from Schoharie county. We insert here as example a section which we have measured in the abandoned quarries and the river bank at Aqueduct and Rexford near Schenectady, in descending order:

1	Argillaceous shale	12′	=	12′
2	Grit banks, about 1 foot thick with shale intercalations ½ foot thick	9′	=	21′
3	Shale, argillaceous	14″	=	22′ 2″
4	Grit	3′ 6″	=	25′ 8″
5	Dark argillaceous shale	13′	=	38′ 8″
6	Grit	6″	=	39′ 2″
7	Shale	2′	=	41′ 2″
8	Compact grit	6′	=	47′ 2″
9	Shale	2′	=	49′ 2″
10	Calcareous grit ("bluestone")	2′	=	51′ 2″
11	Dark argillaceous shale	8′	=	59′ 2″
12	Grit bed	6″	=	59′ 8″
13	Dark shale, separated by fault from underlying beds	3′	=	62′ 8″
14	Grit	6″	=	63′ 2″
15	Shale, dark, argillaceous	2′	=	65′ 2″
16	Thin bedded grit	1′ 6″	=	66′ 8″
17	Bluestone	5′	=	71′ 8″
18	Shale	2′	=	73′ 8″
19	Bluestone	1′ 6″	=	75′ 2″
20	Thin alternating beds of grit and shale, banded and wavy	2′	=	77′ 2″
21	Compact beds of bluestone, with a few thin discontinuous shale seams. Beds irregular	9′ 6″	=	86′ 8″
22	Shale	4′ 6″	=	91′ 2″
23	Grit band with distinct plunge structure	6″	=	91′ 8″
24	Shale, dark, argillaceous	2′ 6″	=	94′ 2″
25	Grit bed with one shale seam	3′ 6″	=	97′ 8″
26	Shale, soft dark gray to black argillaceous and sandy shales	90′ +	=	187′ 8″

The constant alternation of more or less coarse sandstone with shales is indicative of a frequent shifting of the conditions, presumably through currents, either reversal (tidal) or continuous currents. There is sometimes clear evidence of absolutely regular or rhythmic shifting. Such a place was for instance observed in an abandoned quarry on the Bozen kill between Altamont and Delanson. The base is here formed by a compact bed of sandstone some 15 feet thick. This sandstone is abruptly followed by dark argillaceous shale in which higher up thin sandstone layers appear, that become more frequent until another thick sandstone bed is formed, like the basal one. This in turn is cut off by a shale, that gradually yields to sand. The whole cycle is in this place repeated three times, shales and sandstones being each of equal thickness, the whole indicating a most remarkable regularity of change of deposition which on account of the very shallow water character of the rocks of that locality, may well have been a condition due to reversal or tide currents.

It agrees well with the evidence of the shallow water or shore origin of the Schenectady shales and sandstones, that they are often densely filled with remains of seaweeds (Sphenophycus latifolius Hall).

In contrast to the Frankfort shales the Schenectady beds have furnished a large fauna, although they had hitherto currently been held to be quite barren. Altogether about 70 species have been found and there appears to be no striking difference in the lower and upper faunas of this great mass of rocks, aside from that of the Indian Ladder beds, which have been separated as a distinct formation.

The following are the faunal lists from the principal localities.

The easternmost outcrops which represent very low beds of the formation are those at *Aqueduct* and *Rexford Flats,* three miles northeast of Schenectady; these have afforded the following association of species:

Sphenophycus latifolius (*Hall*)	(cc)
Azygograptus *sp. nov.*	(r)
Mastigograptus *cf.* simplex *Walcott* (fragment)	(rr)
Climacograptus typicalis *Hall*	(c)
Diplograptus vespertinus *Rued.*	(c)
Lingula rectilateralis *Emmons*	(rr)
Leptobolus insignis *Hall*	(c)
Rafinesquina alternata (*Conrad*) (small)	(c)
Serpulites	(rr)

Cyrtolites *sp.* (very young example)	(rr)
Trocholites ammonius *Conrad*	(r)
Cyrtoceras *sp. nov.*	(r)
Spyroceras bilineatum (*Hall*)	(rr)
Triarthrus becki (*Green*)	(r)
Isotelus *cf.* gigas *Dekay*[1]	(rr)
Primitia (minute form)	(cc)
Eurychilina	(r)
Pterygotus prolificus *Clarke & Ruedemann*	
P. nasutus *Clarke & Ruedemann*	

A much larger collection was obtained two miles farther southwest in the bluestone quarries at the northeastern outskirts of Schenectady, notably the Dettbarn quarry. This has afforded:

Sphenophycus (*Hall*)	(cc)
Mastigograptus *sp. nov.*	(r)
Climacograptus typicalis *Hall*	(cc)
Lasiograptus eucharis (*Hall*)	(c)
Crinoid joints	
Leptobolus insignis *Hall*	(c)
Lingula rectilateralis *Emmons*	(r)
Dalmanella testudinaria (*Dalm.*) (small)	(c)
Conularia trentonensis *Hall var.* multicosta *nov.*	(r)
Modiolopsis *cf.* modiolaris (*Conrad*)	(c)
Saffordia ulrichi *nov.*	(rr)
Cyrtoceras *sp. nov.*	(c)
Spyroceras *cf.* bilineatum (*Hall*)	(r)
Trocholites ammonius *Conrad* (small)	(r)
Triarthrus becki *Green*	(c)
Trinucleus concentricus *Eaton*	(rr)
Eurypterus pristinus *C. & R.*	(r)
E ? (Dolichopterus) stellatus *C. & R.*	(r)
Eusarcus triangulatus *C. & R.*	(c)
E ? longiceps *C. & R.*	(r)
Dolichopterus frankfortensis *C. & R.*	(r)
D. latifrons *C. & R.*	(r)
Hughmilleria magna *C. & R.*	(cc)
Pterygotus ? nasutus *C. & R.*	(r)
P. prolificus *C. & R.*	(c)
Stylonurus ? limbatus *C. & R.*	(c)

The next series of outcrops which, on account of the southwest dip of the beds, are probably a little higher in the Schenectady formation, are those at Rotterdam Junction. Prosser and Cumings have described (title 33, page 658) a small section nine-tenths of a mile west of the Schenectady pump station, from a deep glen and a long cut on the West Shore Railroad. This section is as follows:

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[1] This is a large complete individual 6.5 inches long, from the "bluestone."

		Feet
I C 1	Covered from level of Mohawk river to Erie canal	25 = 25
C 2	Fine shale which at the base of the glen does not weather readily to soil. Graptolites are fairly abundant	110 = 135
C 3	Very fragile shale exposed in the railroad cut	12 = 147
C 4	Thin sandstone layer	2/12 =
C 5	Shale	1 5/12 = 148 7/12
C 6	Thin layer of sandstone	
C 7	Crumbling arenaceous shale	3 5/12 = 152
C 8	Heavy layer of sandstone by the highway which runs under the railroad track east of the cut	2 = 154

The following fossils are recorded "from a very thin layer of loose-grained, arenaceous shale exposed near the base of the railroad cut on both sides of the track and largely composed of the comminuted fragments of fossils":

1	Triarthrus becki *Green* Numerous small fragments of the pleurae and a few complete specimens of the glabella	(c)
2	Trinucleus concentricus *Eaton* Mostly fragments of the spines and cheeks	(c)
3	Plectambonites sericeus (*Sowb.*) *H. & C.* (?) All the specimens are very small and rather coarsely striated.	(c)
4	Dalmanella testudinaria (*Dalm.*)	(r)
5	Orbiculoidea *sp.*	
6	Monticulipora (Prasopora) lycoperdon *Say* (?)	(r)
7	Crinoid segments	(r)
8	Graptolites	

Cumings (title 44, page 45,) has later described a fine section exposed in a ravine on the northeastern slope of Waterstreet hill. This is as follows:

2 I Rotterdam section

I^1 Near the railroad arch in the bottom of the creek 8 feet of very thin, fragile, dark grayish to bluish black, argillaceous shales with occasional very thin sandy layers, one near the middle of the stratum being about 1 inch thick............. 8′ = 8′

I^2	Heavy, compact sandstone of grayish to greenish blue color, weathering gray to brown	10′ = 18′
I^3	Mainly grayish, friable shales with thin layers of sandstone	12′ = 30′
I^4	Heavy sandstone with intercalated shale	6′ = 36′
I^5	Dark crumbling shale	8′ = 44′
I^6	Shale with mainly thin, but some heavy layers of sandstone	37′ = 81′
I^7	Heavy stratum of sandstone	4′ = 85′
I^8	Shales with some thin layers of sandstone	15′ = 100′
I^9	Thick to thin and broken layers of sandstone	10′ = 110′
I^{10}	Fine shale	5′ = 115′
I^{11}	Thin broken sandstone with crumbling shale	45′ = 160′
I^{12}	Shale	5′ = 165′
I^{13}	Thin sandstone and shale. Base of high waterfall.	5′ = 170′
I^{14}	Thin friable blackish shale by excavation of which from beneath the sandstone above, the fall has been formed	12′ = 182′
I^{15}	Two layers of massive sandstone over which the water falls	8′ = 190′
I^{16}	Thin sandstone layers	2′ = 192′
I^{17}	Clear dark shale	4′ = 196′
I^{18}	Apparently heavy-bedded sandstone weathering to thin often lenticular divisions	25′ = 221′
I^{19}	Shales and thin sandstones	10′ = 231′
I^{20}	Medium thick layers of sandstone with massive 2 foot layer at base and some thin beds of shale, and shaly partings	39′ = 270′
I^{21}	Mostly covered. Highly inclined layers of sandstone exposed in the creek banks 120 feet above No. 20	120′ = 390′
I^{22}	Covered to top of hill but with an occasional exposure of sandstone. 680 feet by barometer	680′ = 1070′

We have carefully collected in this splendid section and found the following fossils:

In I^3	Climacograptus spiniferus *Ruedemann*	(c)
	Eurypterid fragments	
In I^6	Climacograptus spiniferus *Ruedemann*	(c)
	Leptobolus insignis *Hall*	(r)
	Eurypterid fragments	
In I^{11}	Sphenophycus latifolius (*Hall*)	(c)
In I^{13}	Eurypterid fragments	
In I^{15}	Sphenophycus latifolius (*Hall*)	
In I^{20}	Sphenophycus latifolus (*Hall*)	(cc)
	Callograptus multiramosus *nov.*	(rr)
	Rhytimya *sp.*	(rr)
	Eurypterus megalops *Clarke & Ruedemann*	(rr)

Eusarcus triangulatus *C. & R.*	(r)
Dolichopterus frankfortensis *C. & R.*	(c)
Hughmilleria magna *C. & R.*	(c)
Pterygotus prolificus *C. & R.*	(c)

In following the dip of the rocks, a long series of outcrops were found beginning at Duanesburg, about ten miles west-southwest from Schenectady, and extending about four miles along the railroad to Delanson. The dip is too small to measure accurately, different measurements giving from 1° to 2°, but it is safe to assume that these outcrops which are halfway between the lower beds at Schenectady and the top of the formation at the Helderbergs are 1000 feet above the base.

In a bluestone quarry just above the station at Duanesburg about 40 feet of thicker and thinner, partly coarser sandstone beds with intercalated gray, argillaceous and often also arenaceous shales are exposed. The sandstone beds are distinctly lenticular, rapidly thinning out and swelling up in the quarry face and carrying numerous mud pebbles near their surfaces. The shaly layers show fine cases of mud-flow and the whole character of the beds indicates a rather shallow, current or wave-swept sea. The shale seams are profusely filled with seaweeds and fragments of eurypterids.

The following species were obtained:

Sphenophycus latifolius (*Hall*)	(cc)
Climacograptus bicornis *Hall*	(r)
Camarotoechia *sp. fragments*	
Dolichopterus frankfortensis *Clarke & Rued.*	(c)
Eusarcus triangulatus *C. & R.*	(c)
Stylonurus ? limbatus *C. & R.*	(r)
Hughmilleria magna *C. & R.*	(c)
Pterygotus prolificus *C. & R.*	(c)
P. ? nasutus *C. & R.*	(r)

The beds can be followed along the Schenectady branch of the Delaware & Hudson Railroad in a continuous exposure to Delanson, without any change in lithic or faunal character. Following then the southwest dip no outcrops are met with until the Schoharie valley is reached, where a number of small exposures are observed in the river bank above Schoharie Junction. These represent the uppermost portion of the Schenectady beds and can not be more than 300 feet below the top, or the boundary with the Brayman shales in the hills to the east and west of the valley. The beds are still the same alternating thick impure sandstones and dark gray to black shales. It is, however, obvious that the sandstones have become more silicious and are prevailingly gritty, often coarse and assuming the character of an arkose, as notably at Duanesburg. The top layer of the sandstones frequently contains numerous mud pebbles inclosed in the sandstone.

The following fossils were collected along Schoharie creek:

Sphenophycus latifolius (*Hall*[1])	(r)
Climacograptus typicalis *Hall*	(c)
Taeniaster schohariae *nov.*	(rr)
Conularia trentonensis *Hall var.* multicosta *nov.*	(rr)
Eurypterida: Dolichopterus frankfortensis; Pterygotus *sp.*	

While in the Schoharie valley the Schenectady beds can not be followed to their contact with the overlying Brayman shales, this can be done along a small northern branch of the Cobleskill between Central Bridge and Howes Cave, which has been pointed out by Grabau (title 56, page 102) as an excellent exposure of the Brayman shales. Here about 120 feet of Schenectady shales and sandstones are exposed in the ravine above and below the road. The lower portion consists prevailingly of dark gray to brownish green, sandy shales with black argillaceous shales in thinner seams. These change upward into purely sandy shales, which grade into a sandstone about 20 feet thick that is followed by the Brayman shale. The lower shales furnished great quantities of Sphenophycus latifolius and many fragments of eurypterids, among these chelicerae of Pterygotus, and carapaces of Pterygotus prolificus, Eurypterus pristinus, Dolichopterus cf. frankfortensis and Hughmilleria cf. magna. These eurypterid remains could be traced into the bottom of the topmost sandstone bed. Thus we see that here the eurypterid fauna indicative of the Schenectady formation reaches close to the Brayman shales which are supposed to be of Upper Siluric age (see postea page 54).

Another series of outcrops of the middle and lower Schenectady formation is found along the Schoharie creek from Central Bridge to Fort Hunter, at the mouth of the creek. About seven and one-half miles south of Fort Hunter the contact of the Canajoharie shale with the Schenectady is a very distinct one. The section at this contact in a cliff on the western side of the creek, three miles south of Mill Point, has been described by Prosser (1900, page 470), as follows:

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[1] This is the type locality of the species. Hall states of the occurrence of the latter: "This species occurs in considerable abundance near Schoharie, in the bed of the creek, in the central part of the Hudson River group. I have not seen it in any other locality." We have not been able to find Gebhard's old locality at Schoharie, but as is seen from the lists, have observed this remarkable seaweed in sometimes immense quantities in other outcrops, as at Kellum's quarry near Schenectady and in the Rotterdam Junction section.

		Feet
45X^1	Clear black shale from the water to the base of lowest sandstone stratum in the cliff, 114′ by level and 105′ by barometer. At the sandstone stratum there is a decided lithologic break from the black argillaceous shales below. Utica shale........................	114 = 114
X^2	Grayish sandstones alternating with bluish argillaceous shales to the top of the cliff. Hudson River formation.................	195 = 309
X^3	Mostly covered from the top of the cliff to the highway	15 = 324
X^4	Occasional ledges of sandstone show on the side of the hill from the highway nearly to its top. Hudson River formation..........	120 = 444

From this point up the river a splendid series of exposures of the Schenectady formation is furnished by the river banks. The section from Burtonville (formerly Burton's bridge) to Esperance has already been described in detail by Mather (title 2, page 379). Hundreds of feet of rock are here exposed in magnificent cliffs; on investigation they prove, however, a monotonous alternation of sandstone or grit beds with shales with an extreme scarcity of fossils. As far as fossils were observed (a few traces of Climacogr. typicalis in the upper layers and Sphenophycus latifolius in the lower shales), they show the great uniformity of the fossil content throughout the entire series of beds here comprised as Schenectady shale.

A third group of fossiliferous outcrops has been observed by us five to ten miles south of Schenectady, directly in front of the Helderbergs, along the Normanskill and its branches, the Bozen kill and the Vly near the villages of Altamont, Guilderland and Voorheesville. We have already described on page 41 the remarkable alternation of sandstones and shales at the Bozen kill. Continuous outcrops ranging through 200 and 300 feet of rock are found in the upper branches of this kill west of Altamont, which form deep ravines in the lower slope of the Helderberg escarpment. These beds consist prevailingly of bluish and greenish gray shales with several intercalations of sandstone beds, the latter reaching

15 feet in thickness. The beds are nearly barren; only a few fragments of eurypterids were found in the lowest portion. More fossiliferous proved the excellent exposures along the Vly beginning at the fall a mile below Voorheesville. These beds are from 500–600 feet or more from the base of the Upper Siluric beds (Manlius waterlime) of the Helderbergs. The beds of that section are at the western edge of the Appalachian folds of the slate belt of New York and still slightly disturbed by small folds and some overthrusts of probably small throw. The upper beds of this section, which comprises about 200 feet, consist of fossiliferous black to grayish argillaceous shales with several sandstone intercalations and the lower beds of black shales with but few and thin sandstone beds. These shales, of which 80 feet are exposed in the steep eastern bluff of the creek, were formerly referred by the writer (title 47, page 532) on account of their lithic character and fossil contents to the Utica shale. We have now a much larger fauna from this section at our disposal which, with our present knowledge of the shale faunas, throws a different light upon the question of the age of these shales. The latter contain:

Diplograptus vespertinus *Rued.*	(c)
Diplograptus (Mesogr.) putillus *Hall*	(cc)
Climacograptus typicalis *Hall*	(c)
Leptobolus insignis *Hall*	(r)
Minute individuals of Rafinesquina	
Pterinea (Prolobella) trentonensis *Conrad*	(r)
Orthoceras *sp. nov.* ("Endoceras proteiforme")	(c)
Lepidocoleus jamesi *H. & W.*	(r)
Primitia *sp.*	

The sandstone layers of the upper portion have furnished:

Climacograptus typicalis *Hall*	(c)
Hughmilleria *cf.* magna *C. & R.*	(r)

An excellent section leads from these beds up to the Upper Siluric along a branch of Black creek at the Indian Ladder. The beds here exposed have furnished a different fauna and are described further on (p. 50) as Indian Ladder beds.

The combined faunal list of the Schenectady formation is:

Sphenophycus latifolius (*Hall*)
Dictyonema multiramosum *nov.*
Azygograptus *sp. nov.*
Mastigograptus *nov. cf.* simplex *Walcott*
M. *sp. nov.*

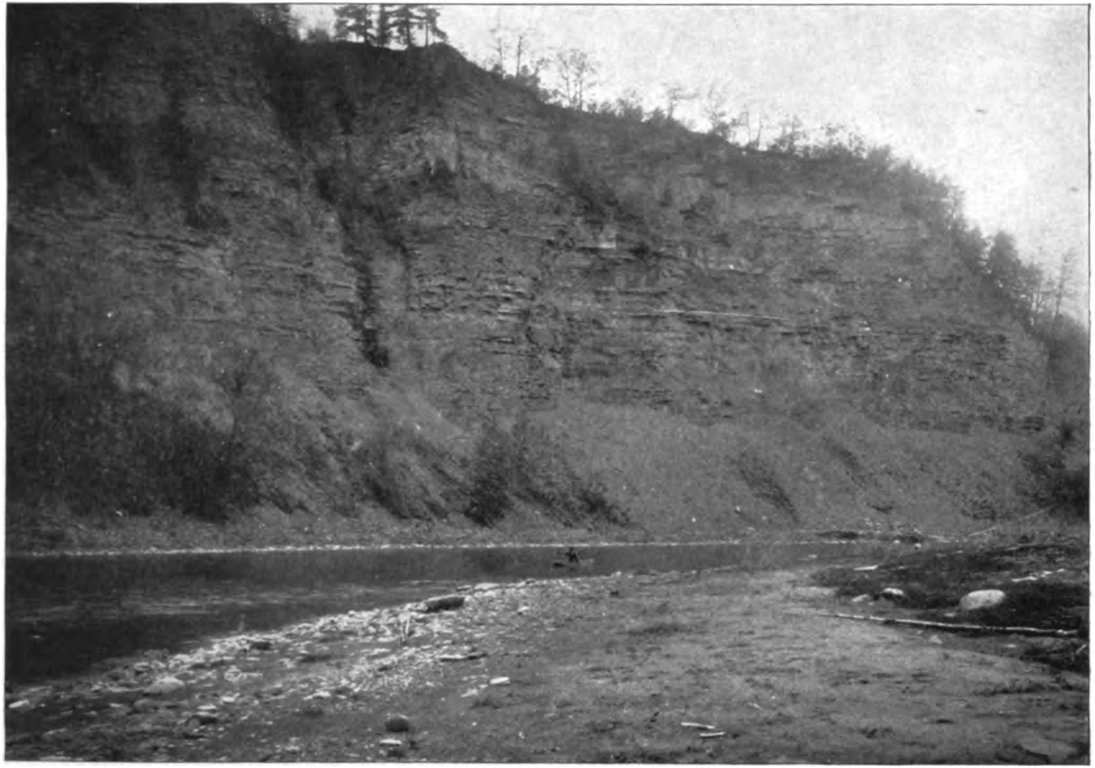

Figure 4 Bega's cliff on Schoharie creek. Canajoharie shale at base; Schenectady beds above.

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Diplograptus vespertinus *Rued.*
Climacograptus bicornis *mut.* ultima *nov.*
C. typicalis *Hall*
Lasiograptus eucharis (*Hall*)
Crinoid joints
Taeniaster schohariae *nov.*
Lingula rectilateralis *Emmons*
Leptobolus insignis *Hall*
Dalmanella testudinaria (*Dalman*)
Rafinesquina ulrichi *James* (typical)
Plectorthis plicatella *Hall*
Orbiculoidea *sp.*
Conularia trentonensis *Hall var.* multicosta *nov.*
Serpulites *sp.*
Saffordia ulrichi *nov.*
Cyrtolites *cf.* ornatus *Conrad*
Cyrtoceras *sp. nov.*
Spyroceras bilineatum (*Hall*)
Trocholites ammonius *Conrad*
Triarthrus becki (*Green*)
Isotelus gigas *Dekay*
Trinucleus concentricus *Eaton*
Primitia
Eurychilina *cf.* subrotunda *Ulrich*
Eurypterus pristinus *Clarke & Ruedemann* [1]
E. megalops *C. & R.*
E ? (Dolichopterus?) stellatus *C. & R.*
Eusarcus triangulatus *C. & R.*
E ? longiceps *C. & R.*
Dolichopterus frankfortensis *C. & R.*
D. latifrons *C. & R.*
Hughmilleria magna *C. & R.*
Pterygotus nasutus *C. & R.*
Stylonurus ? limbatus *C. & R.*

The dominant elements of this large fauna are certain Canajoharie and Utica shale species on one hand, and the eurypterids on the other. The former elements are the species of Mastigograptus, Diplograptus vespertinus, Climacograptus typicalis, Lasiograptus eucharis, Leptobolus insignis, Trocholites ammonius[2] and Triarthrus becki. These are also the most frequent species, and the entire fauna receives thereby a distinct Canajoharie-Utica aspect. But we also note in the congeries of forms a number of species that are not observed in either the Canajoharie or the Utica, but are known only from the Trenton. Such species are Lingula rectilateralis, Conularia trentonensis, Spyroceras bilineatum, Trinucleus concentricus, Eurychilina. It is mainly the evidence from these fossils that indicates the Trenton age of the Schenectady formation. Finally there is a strong element of entirely new species, giving the Schenectady beds a distinct character of its own; this element consists of a few rare species, as Dictyonema multiramosum, Taeniaster schohariae, Saffordia ulrichi, and especially of the eurypterids. It is true the Echinognathus clevelandi Walcott, of the Utica shale of Holland Patent, N. Y., may be contained in this Schenectady fauna, and thus also one eurypterid at least be a Utica element, but there is still no doubt that the eurypterids of the Schenectady beds constitute a strong distinctive feature from the Utica fauna as known to us at present.

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[1] The eurypterids are described and figured in the forthcoming Memoir on the Eurypterida of New York by Clarke and Ruedemann.

[2] Trocholites ammonius Hall is a form that probably occurs entirely or mainly below the Utica in the Canajoharie shale. Its type localities (title 3, p. 309) are the East Canada creek, Canajoharie and Coldspring, all three localities of shales older than the Utica.

If we attempt to compare this formation with others outside the State, we find similar shale beds of upper Trenton age in the lower third of the Martinsburg shale (title 62, page 62) in Pennsylvania, extending thence probably into the Martinsburg shale of New Jersey and south into Maryland.

INDIAN LADDER BEDS

The best section known to us leading from the Schenectady beds up to the Upper Siluric beds, is along the upper left branch of Black creek forming the fall and deep ravine at the Indian Ladder near Meadowdale, Albany county, N. Y. The section comprises about 410 feet (aneroid measurement), of which the lowest 100 feet are dark gray to black argillaceous shales with two thick sandstone bands (each about 4 feet), while the next 100 feet are of a character not met with in other outcrops of the Schenectady beds. They consist of rapidly alternating dark gray shales and thin rusty looking, somewhat calcareous sandstone layers, ½ to 1 inch or more thick. The uppermost part of this portion becomes quite sandy. Nearly 100 feet are there covered, while some 120 feet at the top consist of prevailingly heavy sandstone beds with intercalated dark arenaceous and argillaceous shales, and an occasional thin limestone band. The top is formed by a white hard sandstone bank 3½ feet thick and consisting largely of rounded sand grains. This is separated by shale, one layer of which consists of pyrite, from an underlying gray sandstone bed, also composed of rounded grains. The sandstone beds of this upper part of the formation are extremely irregular courses; in one case a bed was seen to run out within 10 feet from 4 feet to ½ foot.

These beds present an extremely barren aspect; the only observation of fossils in them of which we are aware is that by Walcott (title 17, page 345) who states: "The only fossils I found at this locality were Orthis testudinaria and Trinucleus concentricus." Very thorough search has furnished us a small graptolite faunule in the shales of the lower 200 feet and another faunule in the thin calcareous sandstone intercalations of the second hundred feet. A few bands of the latter proved to be covered with the remains of a microfauna, especially small crinoid joints.

The shale has furnished:

Dictyonema arbuscula *Ulrich*	(r)
Diplograptus peosta *Hall*	(r)
Dicranograptus nicholsoni *Hopkinson* (typical)	(rr)

The sandstone contains a pronounced microfauna which has been kindly determined for us by Doctor Ulrich as follows:

1	Columns and calyx plates of a cystid allied to Cheirocrinus	(r)
2	Very pentagonal columns	
3	Small Heterocrinus columns	(cc)
4	Callopora nealli (*James*) *Ulrich*	
5	Arthrostylus tenuis *Ulrich*	
6	Helopora *n. sp.*	
7	Rhinidictya *cf.* parallela (*James*)	
8	Rafinesquina ulrichi (*James*)	(cc)
9	Plectambonites *nov.* (= centricarinatus *nov.*)	(c)
10	P. plicatellus (*Ulrich*)	
11	Dalmanella multisecta (*Meek*)	(c)
12	Lepidocoleus jamesi (*Hall & Whitfield*)	(c)
13	Ceratopsis chambersi (*Miller*) (typical)	(c)
14	Trinucleus bellulus *Ulrich*	(c)
15	Acidaspis crossota *Locke*	(c)
16	Calymmene (Cincinnati Eden species)	

We also had a Tentaculites cf. flexuosa Hall, a small Hyolithes, fragments of Ceraurus pleurexanthemus Hall and small cranidia of a Dalmanites (Pterygometopus).

Doctor Ulrich has determined the horizon as corresponding to the lower third of the Southgate shale of the Eden group at Cincinnati.

A comparison of the fossil list here given with that of the Schenectady beds shows at once that the " Frankfort " beds of the lower Mohawk valley contain two distinct faunas. The beds at the Indian Ladder also differ in their lithologic aspect; it is therefore safe to distinguish them as a separate unit, for which the name *Indian Ladder* beds is here proposed.

The Indian Ladder fauna is markedly distinct from the Schenectady fauna in the absence of all the dominant forms of the latter, as notably the eurypterids, Climacograptus typicalis, Triarthrus becki, Trocholites ammonius and the seaweeds. It consists on the other hand of a congeries that has hardly any members in common with the Schenectady beds. Much of this is clearly due to a different facies or different marine conditions, at least in the contents of the rusty limestone bands; for instead of the mud-loving linguloids and lamellibranchs of the Schenectady beds, we find here the strophomenoids and orthoids, indicating clearer water. The novel element of this faunule is represented principally by bryozoans, brachiopods, the ostracod Ceratopsis chambersi and the trilobites (Acidapsis crossota, Trinucleus bellulus) and the reappearance of such Trenton forms as Dalmanites callicephalus and Ceraurus pleurexanthemus. Also the graptolite faunule of the shale is totally different from that of the Schenectady beds. In Dicranograptus nicholsoni it contains an upper Trenton and lower Utica element, that here reappears after a long interval, in Diplograptus peosta, the first forerunner of the Lorraine fauna and in Dictyonema arbuscula, a form of the middle Eden shale of Ohio. The combined evidence of the whole fauna is that the Indian Ladder beds are younger than the Schenectady beds, not a mere different facies of the same, but still older than the typical Lorraine.

The horizontal extension of the Indian Ladder beds in the exposures at the base of the Helderberg escarpment seems to be but very restricted. In the section obtained along the roads south of Altamont, only four miles west of the Indian Ladder,

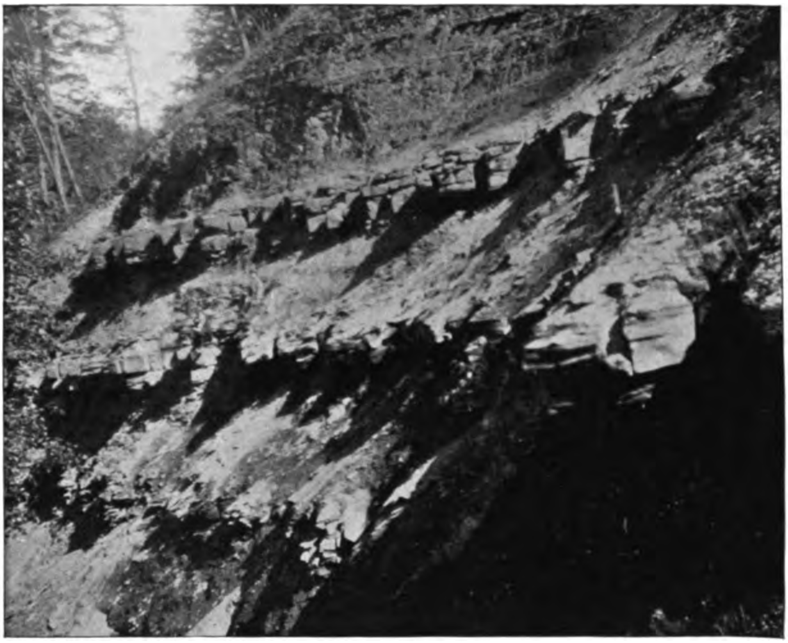

Figure 5 Upper part of type exposure of Indian Ladder beds at the Indian Ladder, showing the alternating shale and thin fossiliferous limestone beds

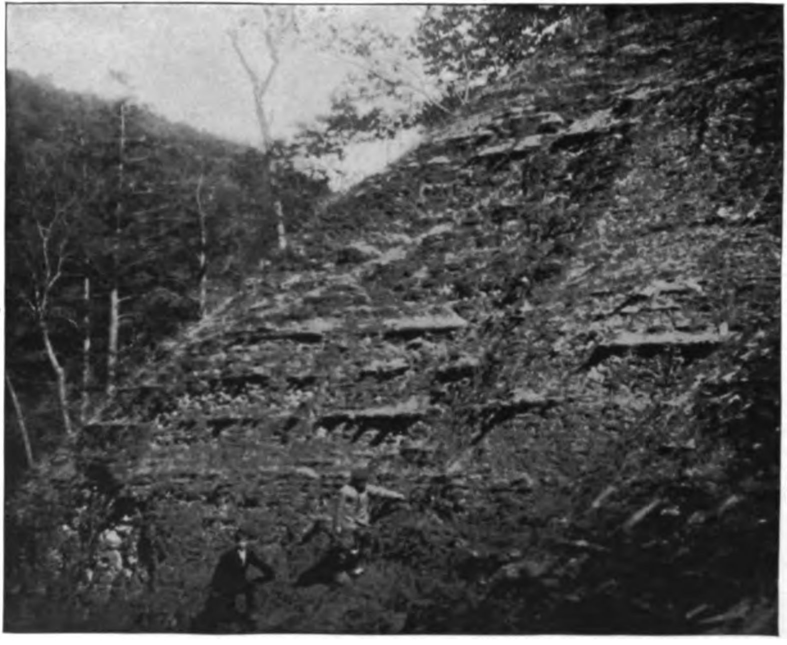

Figure 6 Lower part of the same exposure, showing the thick-bedded sandstone with shale alternations

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Sphenophycus latifolius was observed only 180 feet below the Manlius limestone. Since we have not observed this fossil in the Indian Ladder beds and consider it as characterizing the Schenectady formation, it would follow that the Indian Ladder beds are here already reduced to less than 200 feet in thickness. The orange colored rusty limestone bands of the lower Indian Ladder formation were in this section observed at several places above the Sphenophycus beds.

Westward between Altamont and Schoharie the uppermost part of the Lower Siluric is nearly everywhere found buried under drift. In the road-ditch halfway between East and West Township the characteristic orange colored limestone was observed only 10 feet below a ledge of Manlius limestone.

To the east of the Indian Ladder the only opportunity for the observation of the Indian Ladder beds is afforded by the New Salem sections described by Prosser and Rowe (title 34, page 334). The authors describe there two sections, one the Countryman Hill section, and another south of New Salem. In the former section 57 feet of "bluish gray, fairly massive sandstones which alternate with dark colored argillaceous shales," are cited as representing the Lower Siluric. These are separated by a covered interval of 10 feet from the Manlius limestone. In the other section, which is but half a mile to the east, the contact between the Lower Siluric and the overlying beds is shown. Prosser and Rowe describe the lower part of the sections as follows (op. cit. page 338):

		Feet
B4	Thin bedded dark blue limestone. *Tentaculite limestone*	32 1/2
B3	Drab, impure limestone, well exposed in the run at the foot of the cliff. *Waterlime*..........	6 1/2
B2	Greenish sandstone to coarse arenaceous shale containing plenty of iron pyrites, 10 inches in thickness. Possibly it represents the attenuated Clinton formation....................	1/2
B1	Dark blue to olive tinted argillaceous shales well exposed in the steep banks of the brook. *Hudson River shales*.....................	90

A third outcrop of the Lower Siluric shales is found between these two in the culvert and ravine just south of New Salem at the new State road. Here about 20 feet of dark shales with a few sandy layers are exposed, which extend within 15 feet from the Manlius (Tentaculite) limestone.

None of these three localities has furnished the writer any fossils save a few small crinoid joints in the last mentioned; hence the fossil evidence leaves the question of the correlation of these beds open. The absence of the Sphenophycus latifolius, of fragments of eurypterids and Climacograptus typicalis would, however, indicate that these beds belong to the Indian Ladder beds which for the greater part are entirely barren. Lithologically they also lack the orange colored rusty thin limestone bands which characterize the lower portion of the Indian Ladder section. It is, however, quite apparent that the New Salem sections do not reach far enough down into the Indian Ladder beds to expose these fossiliferous bands. The beds of the Countryman Hill section correspond to the upper beds of the Indian Ladder section.

A noteworthy feature of the two sections of the Lower Siluric beds at New Salem is the horizontal change from the prevailing thick sandstone beds of the Countryman Hill section to the dark shales of the other sections in the astonishingly short distance of less than half a mile.

Brayman shales

The status of the Brayman shales has been lucidly brought up to date by Grabau (title 56, page 101). He says:

> These with the exception of the basal sandstones, are the only beds of the Salina period occurring in this region. They have been variously described in the literature as Clinton shales, pyritiferous shales, Salina shales, etc. The name Brayman shales is chosen for them from the village of Braymanville on the Cobleskill, between which place and Howes Cave they are well exposed. As the shales have so far proved unfossiliferous their exact equivalency is somewhat uncertain. From their position immediately below the Cobleskill limestone it may be confidently inferred that they are of Salina age, but whether they represent the Bertie waterlime of Buffalo, which is the immediate predecessor of the Cobleskill of that region, or whether they are of somewhat earlier age is a question difficult to determine. That there is a slight hiatus between the Brayman shales and the Cobleskill seems to be indicated by the fact that the upper bed of these shales is somewhat conglomeratic, with rounded or elongate pebbles of clay shale inclosed in a dark matrix, partly a calcareous sand and containing numerous scattered, rounded quartz grains. This indication of wave activity at the end of deposition of the Brayman shales and the want of transitional beds between the clay shale and the lime sandrock (Cobleskill) suggest that there is a short time interval unrepresented. This fact, together with the

distinctive character and local development of these shales, demands their description under a separate name, as a local member of the Salina series of deposits, whose exact equivalent in the complete Salina series of Central New York is doubtful.

The main mass of the Brayman shale is an olive or grayish clay rock often alternating with bluish beds and weathering to a lighter color, and having the appearance of a solid mudbank. Concretions of iron pyrites are very abundant and of all sizes, though generally not much larger than a man's fist. The pyrite is commonly an aggregate of crystals, often of considerable size, the cube and pyritohedron being about equally represented. Exposed portions rapidly oxidize changing to an ochery color, and commonly stain the adjoining shales. As already noted, no fossils have yet been found in this formation.

Near Mix and O'Reilly's quarry northeast of Schoharie, Hartnagel's measurement showed 27 feet of these shales. This gives a decrease of 13 feet in a distance of 5 miles. At this point, near the crusher, the contact with the underlying sandstone is well exposed, the two series of strata being absolutely conformable. The surface of the sandstone, exposed for several hundred yards, appears to be a perfectly normal deposition surface, and no trace of erosion, such as we might expect if there was an interval covering Lower and Middle Siluric time, is visible. Moreover the sandstone is pyritiferous like the shale, and no fragments of the lower rock are found in the Brayman shales. Neither does the surface of the top sandstone layer show traces of weathering before the deposition of the Brayman shales.

It is inconceivable that the surface of this sandstone even if worn down to a uniform stratum, should be swept absolutely clean before the shales were deposited, so that no fragments of sandstone are found in the shale. It is clear that all the facts point to the intimate relationship between the upper beds of sandstone and the Brayman shales, making these sandstones of Upper Siluric (Salina) age. The unconformable contact between these sandstones and the Champlainic beds (Lorraine) must be looked for some distance down in the sandstone series.

The most easterly extension of the Brayman shales, so far as has been observed, is according to Hartnagel . . . near Gallupville, 5 miles east of Schoharie, showing that the extreme eastern extension of the great Salina beds of New York can not be far from the town of Knox, Albany county, at which place it is quite likely that the Cobleskill slightly overlaps the Salina. Both of these formations are absent at Altamont, a few miles farther east, and the Rondout is seen resting directly on the Lorraine beds.

The age of the shales here considered has been variously judged. The name pyritous or pyritiferous shales was applied to this formation by the early geologists, and since it occurred below the Coralline or Cobleskill limestone, which was regarded as of Niagara age, and above the Shawangunk grit, which was supposed to be the equivalent of the Oneida conglomerate of central New York, its age was assumed to be Clinton. Recent investigations by Ulrich and Schuchert,[1] and by Hartnagel, have shown that the formation in question is of late Siluric age, the former authors regarding it as a part of the Cobleskill and including it within the Manlius series, while Hartnagel, Clarke and others regard it of Salina age. As will be shown presently, it is probably the partial equivalent of the lower cement bed of Rosendale which in turn represents a part, but probably not a whole, of the Bertie waterlime series of western New York.

It is seen from this discussion that the Brayman shales rapidly disappear eastward and that they have been correlated with the Salina on account of their position below the Cobleskill limestone. Grabau has argued that the Brayman is more closely united with the underlying sandstone of the "Lorraine" beds than with the overlying Cobleskill limestone. For that reason, he would transfer these sandstones into the Upper Siluric (Salina) age,[2] expecting to find the unconformable contact with the "Lorraine" beds below them. We have, however, pointed out in the description of the Central Bridge section, that the eurypterids of the Schenectady shale continue into the lower part of this sandstone, and that the sandstone beds of the top of the Schenectady shale in that section are also united with the Brayman shale by their pyrite nodules, exactly as in Mix and O'Reilly's quarry at Schoharie (Grabau, page 103). One would, from this evidence, rather infer that the top sandstone of the "Lorraine" (Schenectady) shale, by its close relationship to the Brayman shale, draws the latter into the Lower Siluric. No fossils have been found in the Brayman shale and the formation has not been directly traced eastward or westward into another formation, thereby revealing its true age by direct evidence.

We have therefore in the correlation of these shales to rely for the present entirely on indirect evidence.

In the attempt to trace the shale eastward along the foot of the Helderberg escarpment outcrops fail outside the Schoharie recess in the escarpment until the Indian Ladder and the New Salem sections are reached, where 10 inches of "greenish sandstone to coarse arenaceous shale containing plenty of iron pyrite" is found between the top of the Indian Ladder beds and the waterlime. This bed corresponds in its lithic character and aspect, position and especially also in the strong pyrite content so much to the Brayman shale, that it is a fair inference to consider it as the last eastern trace of the formation.[1] It is here as sharply separated from the overlying waterlime (Rondout waterlime), as it is from the Cobleskill beds at Schoharie and it is likewise sharply separated from the underlying Indian Ladder beds.

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[1] Ulrich and Schuchert, in their "Seas and Barriers," accepted merely previous determinations. R.

[2] Grabau follows here merely the general though unfounded assumption of the Salina age of the Brayman shale. Assuming that the sandstone is of Ordovicic age, the same line of arguments would show the Brayman shale to be of Ordovicic and not of Salina age.

Extending so far east beyond the Cobleskill limestone, it is noncontiguous with the latter and independent from it; but it is also to be noted that the bed overlies both the Schenectady shale (at Schoharie) and the Indian Ladder beds at the Indian Ladder, which would seem to make it independent from the Schenectady shale.

Westward from the typical outcrops of the Brayman shale in the Helderberg recesses of the Schoharie creek and Cobleskill, we are not aware of any other outcrops but that at Sharon Springs exposing the contact of the "Frankfort" shale with the overlying beds. At Sharon Springs, both Mr Hartnagel and the writer have noted that the basal beds of the waterlime (corresponding to either the Bertie waterlime or the Camillus) are largely composed of greenish, olive and bluish clay shale resembling the Brayman shale, but lacking the pyrites, and apparently passing by gradation into the typical waterlime. The inference would be that in this locality, which is 10 miles northeast of the Central Bridge outcrop, where the Brayman shale is 27 feet thick, the Brayman shale is merged into the lower Salina beds and this is probably the most potent argument that can be brought forward for a correlation of the Brayman shale with the Salina beds, especially since the thickness of the waterlime at Sharon Springs (about 30 feet) roughly corresponds to that of the Brayman shale at Brayman and Central Bridge.

But the absence of the pyrite in the basal waterlime at Sharon Springs and the restriction of the bluish shales to the base would suggest that we here have possibly reworked Brayman shales before us.

Mr Hartnagel has observed that most formations overlying the Frankfort shales are charged with the iron pyrite at their base, as the Oneida conglomerate in the Frankfort section. It then is probable that the Frankfort shale is the source of this pyrite and that the pyritiferous layer capping the Frankfort, Schenectady and Indian Ladder beds is a residual clay representing the long hiatus that corresponds to the remainder of the Ordovicic and the greater part of the Siluric. The thickness of the Brayman shale, its lithic character and overlapping distribution argue in favor of its residual origin. In that case the presence of the pyrite in both the Brayman shale and the top sandstone of the Schenectady shale would lose its force as a connective of the two formations and the exact age determination of the shale again becomes impossible from that criterion.

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[1] Harris (Bull. Am. Pal. no. 19, p. 25) has indeed compared the bed with the Brayman shale, while Grabau (title, p. 292) considers it as the "basal clastic beds of the Rondout."

But the facts remain that the Brayman shale, where it is thickest and typically exposed, rests upon Schenectady beds, or beds as old as the upper Trenton age and that there is apparently, as pointed out by Grabau, no erosion interval observable between the top sandstone of these Schenectady beds and the Brayman shale; and the conclusion is hence permissible that the Brayman shale should be correlated with some part of the Upper Ordovicic (i. e., the Cincinnatian) rather than the Salina. My correspondence has shown that Doctor Ulrich and the author had reached the same conclusion independently at their separate visits to the Schoharie region, and Doctor Ulrich has in the Revision of the Paleozoic Systems correlated the Brayman shale with the Frankfort (title 69, plate 27).

Snake Hill beds

The separation of the Canajoharie beds from the Utica formation necessitates the recognition and definition of a further unit in the slate belt of the upper Hudson River region. A large fauna had been collected from these beds by the author about the mouth of the Mohawk river and published in 1901 in New York State Museum Bulletin 42. The principal localities were the east and north shores of Green island, Van Schaick island, Block island, Mechanicville, and Brothers' quarry at Troy. On the strength of these faunules the shales had been referred to the lower and middle Trenton (Watervliet, Port Schuyler), Utica and Lorraine. In Memoir 11, page 29, this belt of shale has, on the evidence from the graptolites, been correlated with the upper Trenton and the name Magog shale from the graptolite locality Magog in Quebec applied to it. Investigations since carried on in this slate belt about Saratoga lake have furnished a large addition to the fauna hitherto known; and by the relations of the beds to the Canajoharie shale and the new fossils discovered the inference of the Trenton age of these shales has been much strengthened.

While we have little doubt of the approximate equivalency of the Magog shale with this shale of the Hudson valley, the fact that the former contains only a graptolite fauna, while the shale in the Hudson valley carries a mollusk fauna and that but few graptolites are common to the shale in Quebec and that on the Hudson, suggests that in the present state of our knowledge, at least, it is more appropriate to distinguish the two terranes by different names, especially also since we do not know whether the two are continuous and deposits of the same basin. Our reason for identifying the two shales was the occurrence in both of certain graptolites, notably Climacograptus caudatus, C. scharenbergi, Cryptograptus tricornis and species of Corynoides. All these are, however, European species which very well might have entered the different channels in the Appalachian system of troughs from the Atlantic basin to the east, as for instance through the St Lawrence region and the New Jersey inlet.

On account of the large faunas obtained on Snake hill on the east shore of Saratoga lake we will designate these shales as *Snake Hill shales*. Their lithologic character and their section on the east shore of Saratoga lake will be fully described in the Schuylerville quadrangle to be published together with the Saratoga quadrangle by Professor H. P. Cushing and the writer.

A large list of fossils were recorded from this formation in a former publication (title 47), but this original list needs revision, since a great many of the species had been only compared with New York Lorraine forms under the assumption of the upper Utica and Lorraine age of the beds. They have largely proven to be earlier species, especially so among the lamellibranchs. Unfortunately these earlier collections will not be accessible again for several years to come. Nevertheless the list gives a fair idea of the aspect and the size of the fauna of the Snake Hill beds. This large fauna has been greatly augmented and partly corrected by the later collections from Snake Hill itself, which are here listed as follows:

Dicranograptus nicholsoni *Hopkinson*	(c)
Diplograptus (Mesogr.) putillus *Hall*	(cc)
Corynoides *sp.*	(r)
Glyptocrinus *sp.*	(r)
Heterocrinus ? gracilis *Hall*	(c)
Cremacrinus *sp.*	(rr)

Carabocrinus *cf.* radiatus *Billings*	(rr)
Edrioaster saratogensis *nov.*	(r)
Paleschara ulrichi *nov.*	(r)
Schizocrania filosa (*Hall*)	(r)
Plectambonites sericeus typus (*Sowerby*)	(cc)
Plectorthis *sp. cf.* whitfieldi (*N. H. Winchell*)	(rr)
Dalmanella testudinaria (*Dalman*)	(cc)
Plaesiomys retrorsa (*Salter*)	(c)
Rafinesquina alternata (*Emmons*)	(c)
Clitambonites americanus (*Whitfield*)	(r)
Parastrophia hemiplicata *Hall*	(r)
Zygospira recurvirostris (*Hall*)	(r)
Whiteavesia cincta *nov.*	(r)
W. cumingsi *nov.*	(c)
Orthodesma ? subcarinatum *nov.*	(c)
Whitella elongata *nov.*	(r)
Clidophorus ventricosus *nov.*	(c)
C. foerstei *nov.*	(c)
Ctenodonta levata (*Hall*)	(c)
C. declivis *nov.*	(r)
C. prosseri *nov.*	(c)
C. radiata *nov.*	(r)
C. recta *nov.*	(r)
C. subcuneata *nov.*	(r)
Lyrodesma schucherti *nov.*	(rr)
Solenomya ? insperata *nov.*	(r)
Cuneamya acutifrons *Ulrich*	(r)
Archinacella orbiculata (*Hall*)	(c)
Cyclonema montrealense *Billings*	(r)
Cyclonema cushingi *nov.*	(r)
Clathrospira subconica *Hall*	(r)
Pterotheca *cf.* canaliculata (*Hall*)	(rr)
Eoharpes ottawensis (*Billings*)	(rr)
Trinucleus concentricus (*Eaton*)	(cc)
Proëtus undulostriatus (*Hall*)	(rr)
Calymmene senaria *Conrad*	(r)
Lepidocoleus jamesi *H. & W.*	(c)
Ctenobolbina subrotunda *Ruedemann*	(r)
Technophorus cancellatus *Ruedemann*	(r)

While the foregoing list cites only the fossils obtained on the cliff and slope of Snake hill, the cliff on the east shore of the lake, north of Snake hill, and the outcrops about Edgewater park on the west side have also furnished faunules that add to the Snake Hill congeries of species, especially to the graptolite biota:

Corynoides calicularis *Nicholson*	(cc)
Dicranograptus nicholsoni *Hopkinson*	(cc)

Glossograptus quadrimucronatus *mut.* pertenuis *Rued.*	
Diplograptus amplexicaulis *Hall*	(c)
D. amplexicaulis *var.* pertenuis *Rued.*	(c)
D. (Mesogr.) putillus (*Hall*)	(c)
Climacograptus scharenbergi *Lapworth*	(r)
C. spiniferus *Rued.*	(cc)
Plectambonites *sp.*	
Archinacella orbiculata (*Hall*)	(c)
Lepidocoleus jamesi *H. & W.*	(c)

The combined fauna of the Snake Hill beds, as known at present, is:

1 Dicranograptus nicholsoni *Hopkinson*
2 Diplograptus amplexicaulis *Hall*
3 D. amplexicaulis *var.* pertenuis *Rued.*
4 D. (Mesogr.) putillus *Hall*
5 Climacograptus scharenbergi *Lapworth*
6 C. spiniferus *Rued.*
7 Cryptograptus tricornis *Carr. mut.* insectiformis *Rued.*
8 Lasiograptus eucharis (*Hall*)
9 Glossograptus quadrimucronatus *Hall mut.* pertenuis *Rued.*
10 Corynoides calicularis *Nicholson*
11 Dawsonia campanulata *Nicholson*
12 Glyptocrinus *sp.*
13 Heterocrinus ? gracilis *Hall*
14 Cremacrinus *sp.*
15 Schizocrinus nodosus *Hall*
16 Carabocrinus *cf.* radiatus *Billings*
17 Edrioaster saratogensis *nov.*
18 Pontobdellopsis cometa *Rued.*
19 Paleschara ulrichi *nov.*
20 Pachydictya acuta (*Hall*)
21 Lingula curta *Conrad*
22 Leptobolus insignis *Hall*
23 Pholidops trentonensis *Hall*
24 Schizocrania filosa *Hall*
25 Plectambonites sericeus typus (*Sowerby*)
26 Plectorthis *sp. cf.* whitfieldi (*N. H. Winchell*)
27 Dalmanella testudinaria (*Dalman*)
28 Plaesiomys retrorsa (*Salter*)
29 Plectorthis plicatella *Hall*
30 Platystrophia biforata (*Schlotheim*)
31 Rafinesquina alternata (*Emmons*)
32 Clitambonites americanus (*Whitfield*)
33 Rhynchotrema inequivalve (*Castelnau*)
34 Parastrophia hemiplicata *Hall*
35 Cyclospira bisulcata (*Emmons*)
36 Zygospira recurvirostris (*Hall*)

37 Whiteavesia cincta *nov.*
38 W. cumingsi *nov.*
39 Orthodesma ? subcarinatum *nov.*
40 Whitella elongata *nov.*
41 Clidophorus ventricosus *nov.*
42 C. foerstei *nov.*
43 Ctenodonta levata (*Hall*)
44 C. declivis *nov.*
45 C. prosseri *nov.*
46 C. radiata *nov.*
47 C. recta *nov.*
48 C. subcuneata *nov.*
49 Lyrodesma schucherti *nov.*
50 Solenomya ? insperata *nov.*
51 Cuneamya acutifrons *Ulrich*
52 Archinacella orbiculata (*Hall*)
53 Cyclonema montrealense *Billings*
54 C. cushingi *nov.*
55 Clathrospira subconica *Hall*
56 Protowarthia *cf.* cancellata (*Hall*)
57 Pleurotomaria *cf.* lenticularis (*Hall*)
58 Murchisonia (Lophospira) uniangulata *var.* abbreviata *Hall*
59 Orthoceras tenuitextum (*Hall*)
60 O. lineolatum (*Hall*)
61 Spyroceras bilineatum (*Hall*)
62 Conularia trentonensis *Hall var.* multicosta *nov.*
63 Pterotheca *cf.* canaliculata (*Hall*)
64 Eoharpes ottawensis (*Billings*)
65 Trinucleus concentricus (*Eaton*)
66 Proëtus undulostriatus (*Hall*)
67 Triarthrus becki *Green*
68 Isotelus gigas *Dekay*
69 Acidaspis trentonensis *Hall*
70 Calymmene senaria *Conrad*
71 Pterygometopus callicephalus (*Hall*)
72 Ctenobolbina ciliata (*Emmons*)
73 C. ciliata *var.* cornuta *Ruedemann*
74 C. subrotunda *Ruedemann*
75 Lepidocoleus jamesi (*Hall & Whitfield*)
76 Turrilepas ? filosus *Ruedemann*
77 Pollicipes siluricus *Ruedemann*
78 Technophorus cancellatus *Ruedemann*[1]

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[1] To this list have to be added a number of interesting species which were obtained by the writer when this paper was already in press, at the excavations for the shops of the Delaware & Hudson R. R. at

In comparing these faunas with that of the Canajoharie shale, we find that most graptolites of the two formations are but little different. Closer scrutiny shows, however, that the Snake Hill beds contain certain forms which do not appear in the Canajoharie beds. The most important of these are: Climacograptus caudatus, C. scharenbergi, Cryptograptus tricornis mut. insectiformis. On the other hand, Climacograptus mohawkensis and Diplograptus quadrimucronatus mut. cornutus are peculiar to the Canajoharie shale. But also the forms which are common to both, show a marked difference in their frequency. Thus of Dicranograptus nicholsoni[1] and Climacograptus spiniferus[2] which are among the most common graptolites of the Snake Hill beds about Saratoga lake, the former is extremely rare in the Canajoharie beds, and the latter only frequent in the lower portion of the Canajoharie beds, about Hudson Falls and Ballston. On the other hand, Lasiograptus eucharis is all but absent in the Snake Hill beds, but well established in the parallel belt of Canajoharie beds, and while Corynoides calicularis occurs in both, C. gracilis, which occurs in the Snake Hill beds in several localities, seems to enter only the lower portion of the Canajoharie beds about Hudson Falls.

Watervliet, N. Y. The species new for this formation collected there are:

Trematis terminalis *Emmons*. Large form approaching T. millepunctata *Hall*

Schizambon fissus *var.* canadensis *Ami*. Large, long-spined specimens

Lingula obtusa *Hall*

Cyrtolites trentonensis *Conrad*. Much flattened specimens

Carinaropsis cf. carinata *Hall*. Large specimens

[1] As we have already noted, this species ranges here even into the Indian Ladder shale. This corresponds to the great range of the species in Europe, where it is cited from the zone of Nemagr. gracilis (corresponding to our Normanskill shale) in Sweden and reaches into the Hartfell shale in Great Britain.

[2] Climacogr. spiniferus was at first distinguished by us as C. typicalis mut. spinifer (title 60, p. 411) to identify a form figured by Hall (title 3, pl. 73, fig. 2a) as coming from Ballston, Saratoga county and which we have found to mark the shales directly overlying the basal Trenton limestone (Glens Falls limestone) at Hudson Falls (Sandy Hill). On account of its stratigraphic importance and apparent constancy of characters for a considerable length of time we prefer to distinguish this type as of specific rank (Cl. spiniferus).

Much more distinct is the difference between the Snake Hill beds and Canajoharie beds in the nongraptolitic portion of the fauna; for the former formation contains a great number of species that have not been observed in the Canajoharie beds, the most important of which are Edrioaster saratogensis, Carabocrinus, Orthis (Plaesiomys) retrorsa, Parastrophia hemiplicata, Zygospira recurvirostris, the many species of lamellibranchs, the trilobites Eoharpes ottawensis, Proëtus undulostriatus, also Pollicipes siluricus, Technophorus cancellatus, and the ostracods. On the other hand, the Canajoharie beds also contain a number of species not found in the Snake Hill beds, as Hyolithes pinniformis, Pterinea (Prolobella?) trentonensis and Pterinea insueta and a number of ostracods (Ulrichia? bivertex, Primitia unicornis).

When we now turn to the question of the relative position of the Snake Hill beds to the Canajoharie beds, we find several lines of evidence.

1 The common occurrence of a great number of fossils in both, which are absent above and below these two formations, as Diplograptus amplexicaulis and Corynoides calicularis, would indicate that both are either subdivisions of one formation or were deposited nearly contemporaneously in adjoining areas. If they are subdivisions of one formation, the faunal evidence would indicate that the Snake Hill beds are the older formation, for they contain in Cryptograptus tricornis, Climacograptus caudatus, C. scharenbergi, Plaesiomys retrorsa, Parastrophia hemiplicata, Edrioaster, Eoharpes ottawensis, etc., elements that indicate early Trenton or Black River age.

2 Geographically the belt of Snake Hill shales lies between the Canajoharie shales on the west and the Normanskill shales on the east. Although the complex folding and faulting of this region is little favorable to the drawing of inferences from the relative positions of the belt, the general observations noted in Bulletin 42, that the older rocks are found in the east and the beds as a rule become successively younger toward the west in the overturned and overthrusted closed folds have thus far proved correct. On the east side of Saratoga lake the Snake Hill and Normanskill shales become

even interfolded so that they form narrow alternating strips. We therefore infer that the Snake Hill beds lie closer to the Normanskill shales than the Canajoharie shales and are older than the latter.

3 At Hudson Falls and near Saratoga the Canajoharie shales rest directly on the Glens Falls limestone. The latter is according to Ulrich's determination, of very early (basal) Trenton age.

Since now the Canajoharie beds rest directly on the Glens Falls limestone and the Snake Hill beds are older than the Canajoharie beds, they must be absent in the western part of the Saratoga basin as well as in the Mohawk valley. Because of the fact that the Snake Hill beds are interfolded with the Canajoharie beds at the lower Mohawk and the western edge of the Hudson valley, we have considered them at first as deposited about the eastern edge of the Mohawk basin and as intercalated there between the Glens Falls limestone and the Canajoharie shale. Subsequent work, however, especially the summer's work of 1911 on the Schuylerville sheet, has shown that these shales reappear in a distinct belt on the east side of the Normanskill belt. They are therefore deposits of the same basin as the Normanskill shale. This inference is in accord with the observation that nowhere Snake Hill beds have been observed between the Glens Falls limestone and the Canajoharie beds, and it also accords with the faunal evidence that the Snake Hill sea had connections toward the north and east and thence received an important portion of its fauna. This latter evidence consists in the presence in the shales of Edrioaster, Carabocrinus, Eoharpes ottawensis and Orthis (Plaesiomys) retrorsa, all of which point to the St Lawrence and Ottawa Trenton rather than to the central New York Trenton. It is also noteworthy in this connection that Proëtus undulostriatus, of which we have obtained a well preserved carapace in the Snake Hill beds, is also known from the black pebbles (Black river?) of the Rysedorph Hill conglomerate and that the latter in its faunal connections also points east. Likewise Climacograptus caudatus is in America known only from the Snake Hill beds and the Magog shales in Canada and is an Atlantic form. Cryptograptus tricornis and Climacograptus scharenbergi have been directly taken from the Normanskill sea.

SUMMARY

The conclusions obtained in the preceding paper are:

1 The lower part of the black shale belt of the lower Mohawk valley hitherto referred to the Utica shale is of Trenton age and therefore here distinguished as *Canajoharie shale* from its typical outcrop at Canajoharie. The Canajoharie shale corresponds roughly to the lower and possibly middle Trenton of Trenton Falls and probably belongs in large part between the two. It disappears westward and is eastward cut off by the Hoffmans Ferry fault, but reappears north of Schenectady from under the Schenectady beds and eastward in the folded shales of the Hudson valley, where it is recognized in the Rural Cemetery beds, formerly referred by the author to the Magog shale of Canada. This belt can in the Hudson valley be followed northward through Saratoga county to Hudson Falls, where it rests on Glens Falls (basal Trenton) limestone.

2 The typical *Utica shale* seems to disappear entirely as it approaches the Hudson valley, probably through nondeposition.

3 The Frankfort shale is absent in the lower Mohawk valley. The shales, hitherto referred there to the Frankfort formation, are of older age. The Frankfort formation, in its restricted conception, soon disappears to the east of the type section near Utica, probably by overlap, and does not seem to have at all extended into the Hudson and Champlain valleys. According to its meager faunule it corresponds to the middle division of the Eden shale at Cincinnati and it may also include the upper Eden.

4 The so-called Frankfort beds of the lower Mohawk have furnished a large fauna that is very distinct from that of the Frankfort shale. Its most striking elements are the *eurypterids* and the seaweed Sphenophycus, but it also contains a number of species that indicate that it can not be younger than upper Trenton age and probably belongs mainly below the upper Trenton. Since these beds are connected by transitional beds with the underlying Canajoharie shale of lower and middle Trenton age, the inference of their middle and upper Trenton age is also supported by the stratigraphic relations. The formation is therefore here given a new name, the *Schenectady* formation. This formation attains a great thickness (approximately 2000 feet) in the lower Mohawk region, but does not extend far westward and ends abruptly eastward against the folded region. It is characterized by numerous intercalations of "bluestone," a calcareous sandstone, by mud-cracks, rapid horizontal alteration of sediments and other features which indicate nearness of the coast. This coast was probably to the east and the great

thickness of the Schenectady beds in this region is due to their formation in a sinking trough parallel to and in front of the Green Mountain-Taconic fold system. The Schenectady beds strike for this reason from north-northeast to south-southwest.

5 The uppermost portion, about 300 feet, of the " Frankfort " beds at their eastern edge in Albany county has been found to contain an entirely different fauna and also to be lithologically somewhat different. This division has been termed here the *Indian Ladder beds.* These rapidly disappear westward, being absent at Cobleskill and probably formed originally a narrow belt extending north-northeast to south-southwest; they are hence for the greater part buried under Devonic rocks in the south, and lost by erosion north of the Helderbergs, and only exposed to view in the Helderberg escarpment. The Indian Ladder beds contain the fauna of the Southgate division of the Eden shale and are hence of the age of part of the Frankfort beds but entirely different from them in their faunal aspect.

6 The *Brayman shales* which were originally referred to the Clinton and later were correlated with the Salina, appear to be the residual pyritiferous clays of the long hiatus corresponding to the time interval from the upper Trenton Schenectady shale to the Cobleskill limestone. They seem, however, sufficiently closely connected with the underlying sandstone at the top of the Schenectady shale to be considered as mainly formed in Upper Ordovicic time.

7 In the Hudson valley a belt of slates, grit and sandstones extends between the Canajoharie shale and Normanskill shale. It is distinguished from both by its fauna, and from the Canajoharie beds in the character of the shale and the greater intercalation of arenaceous beds. This shale which in the Hudson valley is well exposed on Green island, opposite Troy, and at Mechanicville, has received the name *Snake Hill beds* from its very fossiliferous outcrops at Snake hill, on the east side of Saratoga lake. It exhibits in its fauna evidence of being older than the Canajoharie shale and younger than the Normanskill shale and also distinct relations to the basal Trenton of the Ottawa basin, and properly belongs to the Levis basin where it follows the Normanskill shale.

8 The Canajoharie, Utica and Frankfort shales seem to correspond to the three divisions of the Martinsburg shale of Pennsylvania, Maryland and Virginia, or to be a northern continuation of that formation; and the Frankfort shale can also be correlated with the middle part of the Eden shale of the Cincinnatian in Ohio.

Correlation table of the Cincinnatian and Upper Mohawkian groups of the Mohawk valley

OHIO VALLEY	UPPER MOHAWK VALLEY	LOWER MOHAWK VALLEY	PENNSYLVANIA–NEW JERSEY
Eden	Frankfort shale	Indian Ladder shale	
	Utica shale		
Trenton	Upper Trenton ls.	Schenectady beds	Martinsburg shale
	Middle Trenton ls.		
	Lower Trenton ls.	Canajoharie shale	
	Basal Trenton ls.	Glens Falls ls.	
Black River		Amsterdam ls.	Jacksonburg ls.
	Lowville ls.	Lowville ls.	

Table of the Cincinnatian and Upper Mohawkian in the Mohawk valley

SECTION	TRENTON FALLS–UTICA	DOLGEVILLE–LITTLE FALLS	CANAJOHARIE–SHARON SPRINGS	AMSTERDAM–COBLESKILL	SCHENECTADY–INDIAN LADDER
Cincinnatian	Frankfort shale	Frankfort shale	Frankfort shale?		Indian Ladder beds
	Utica shale	Utica shale	?		
Upper Mohawkian	Upper Trenton limestone		?	Schenectady beds	
	Middle Trenton limestone	" Utica shale " Dolgeville beds	Canajoharie shale		
	Lower Trenton limestone	Lower Trenton limestone			
	Basal Trenton ls.	Basal Trenton ls.	Glens Falls ls.	Glens Falls ls.	Glens Falls ls.

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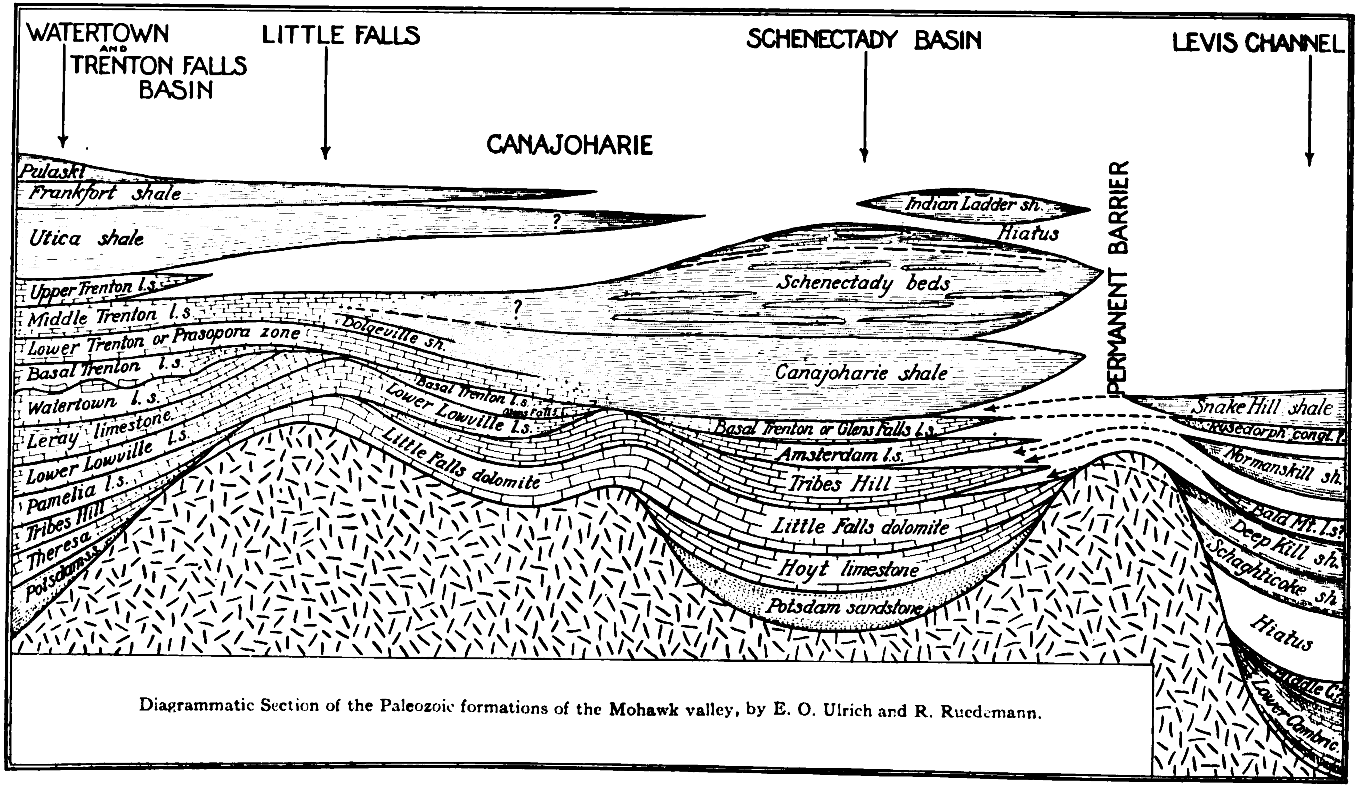

Diagrammatic Section of the Paleozoic formations of the Mohawk valley, by E. O. Ulrich and R. Ruedemann.

Note to diagram

Doctor Ulrich and the writer have represented the stratigraphic results here obtained in the adjoined diagrammatic section of the Eopaleozoic formations of the Mohawk valley. The relations of the formations below the Trenton are reproduced as established through former investigations by E. O. Ulrich, H. P. Cushing and the writer. The relations of the Canajoharie and Schenectady beds to the Trenton limestone of the Trenton Falls basin are represented as described here. The upper Trenton limestone is drawn as abruptly terminating at the eastern edge of the Trenton Falls basin, because Doctor Ulrich failed to find it between Rathbone brook and Middleville, and the Utica shale is shown to diminish rapidly eastward, especially in its lower portion. The amount of its eastward extension in the Mohawk valley at present is not fully known. The Schenectady beds may at their top reach into the upper Trenton age and this transgression into the upper Trenton is indicated by the dotted line. The Indian Ladder beds appear as a lenticular body, since their main extension is in northeastern direction, crossing the east-west sectional plane in a very limited area.

Doctor Ulrich holds from his investigations that the Levis is the second trough east of the Schenectady basin and that the Chazy bay intervenes but is now covered by the overthrust Levis deposits. We have not attempted to introduce this condition on the diagram to the right of the permanent barrier because the exaggeration of the vertical scale would not permit its intelligible representation. The overthrust condition, however, which has brought the formation of the Levis basin in contact with those of the Schenectady basin in Albany and Saratoga counties, is indicated by the arrows showing the direction of the movement. We have further tentatively placed in the series of the Levis channel formations (mainly graptolite shales) a limestone outcropping about Bald mountain. From fossils collected last summer by the writer it is determined as of upper Beekmantown age. The Rysedorph Hill conglomerate, which also outcrops at various localities, belongs with the Levis channel graptolite beds and probably lies between the Normanskill shale and Snake Hill beds.

Bibliography

(1) 1842 **Vanuxem, Lardner.** Geology of New York; Report on the Third District.

(2) 1843 **Mather, W. W.** Geology of New York; Report on the First District.

(3) 1847 **Hall, James.** Palaeontology of New York. v. 1.

(4) 1858 **Billings, E.** On the Asteridae of the Lower Silurian Rocks of Canada. Can. Org. Remains. Dec. III, p. 75.

(5) 1865 **Billings, E.** Geology of Canada, Palaeozoic Fossils. v. 1.

(6) 1873 **Meek, F. B.** Descriptions of Invertebrate Fossils of the Silurian and Devonian Systems. Rep't, Geol. Surv. Ohio. v. 1, pt 2.

(7) 1877 **Whitfield, R. P.** In Lieut. G. M. Wheeler's Report on U. S. Geog. Surv. West of 100th Meridian. v. 4, Pal., p. 19–20

(8) 1879 **Ulrich, E. O.** Descriptions of New Genera and Species of Fossils from the Lower Silurian about Cincinnati. Jour. Cincinnati Soc. Nat. Hist. v. 2.

(9) **Walcott, C. D.** The Utica Slate and Related Formations of the Same Geological Horizon. Albany Inst. Trans. 10. 1–17.

(10) **Walcott, C. D.** Fossils of the Utica Slate. Albany Inst. Trans. 10:18.

(11) 1882 **Miller, S. A.** Description of Two New Genera and Eight New Species of Fossils from the Hudson River Group, with Remarks upon Others. Jour. Cincinnati Soc. Nat. Hist. 5:34.

(12) **Whitfield, R. P.** Geology of Wisconsin. v. 4, Paleontology.

(13) 1883 **Beecher, C. E.** List of Species of Fossils from an Exposure of the Utica Slate and Associated Rocks within the Limits of the City of Albany. 36th Annual Report N. Y. State Mus. Nat. Hist. p. 78.

(14) 1885 **Ford, S. W.** Age of the Slaty and Arenaceous Rocks in the Vicinity of Schenectady, N. Y. Amer. Jour. Sci. 29:397–99.

(15) 1889 **Ulrich, E. O.** Contribution to Canadian Micro-Paleontology, pt II.

(16) 1890 **Stürtz, B.** Bieträge zur Kenntniss palaeozoischer Seesterne. Palaeontographica. 36:234.

(17) **Walcott, C. D.** Value of the Term "Hudson River Group" in Geologic Nomenclature. Bul. Geol. Soc. Amer. 1:335–57.

(18) **Hall, James, & Clarke, J. M.** Palaeontology of New York. v. 8, pt. 1.

(19) 1893 **Beecher, C. E.** On the Thoracic Legs of Triarthrus. Amer. Jour. Sci., Ser. 3, v. 46, 1893; also Amer. Geol., v. 13, 1894; Amer. Jour. Sci., Ser. 3, v. 47, 1894; Amer. Geol., v. 15, 1895; Amer. Jour. Sci., Ser. 4, v. 1, 1896.

(20) **Clarke, J. M.** The Protoconch of Orthoceras. Amer. Geol. 12:112.

(21) **Matthew, W. D.** On Antennae and Other Appendages of Triarthrus becki. Amer. Jour. Sci., Ser. 3, v. 46.

(22) **Ulrich, E. O.** New and Little Known Lamellibranchiata from the Lower Siluric Rocks of Ohio and Adjacent States. Rep't, Geol. Sur. Ohio. v. 7.

(23) 1894 **Clarke, J. M.** The Early Stages of Bactrites. Amer. Geol. 14:37.

(24) Darton, N. H. Preliminary Report on the Geology of Albany County. 13th Annual Report N. Y. State Geologist. 1:229–61.

(25) **Darton, N. H.** Geology of the Mohawk Valley. 1: Herkimer, Fulton, Montgomery and Saratoga Counties. N. Y. State Geol. Rep't 13 (for 1893), p. 407.

(26) **Hyatt, Alpheus.** Phylogeny of an Acquired Characteristic. Proc. Amer. Philos. Soc. 32, no. 143.

(27) 1895 **Ruedemann, Rudolf.** Development and Mode of Growth of the Genus Diplograptus, McCoy. N. Y. State Geol. Rep't 14 (for 1894), p. 15, 217.

(28) **Ulrich, E. O.** Lower Silurian Bryozoa of Minnesota. Geol. Minn. v. 3, pt 1, Paleontology.

(29) **Winchell, N. H., & Schuchert, Charles.** The Lower Silurian Brachiopoda of Minnesota. Geol. Minn., v. 3, pt 1, Paleontology.

(30) 1896 **Harper G. W., & Bassler, R. S.** Catalogue of the Fossils of the Trenton and Cincinnati Periods, Occurring in the Vicinity of Cincinnati, Ohio. Cincinnati, 1896.

(31) **Gregory, J. W.** On the Classification of the Palaeozoic Echinoderms of the Group Ophiuroidea. Proc. Zool. Soc. London, 64:1035.

(32) 1897 **Clarke, John M.** The Lower Silurian Trilobites of Minnesota. Geol. Minn. v. 3, pt 2, Paleontology.

(33) **Prosser, C. S., & Cumings, E. R.** Sections and Thickness of the Lower Silurian Formation in West Canada Creek and in the Mohawk Valley. N. Y. State Geol. Rep't 15 (for 1895), p. 615.

(34) **Prosser, C. S., & Rowe, R. B.** Stratigraphic Geology of the Eastern Helderbergs. N. Y. State Geol. Rep't 17 (for 1897), p. 329.

(35) **Ruedemann, Rudolph.** Note on the Discovery of a Sessile Conularia. N. Y. State Geol. Rep't 15 (for 1895), p. 699.

(36) **Ruedemann, Rudolph.** Evidence of Current Action in the Ordovician of New York. Amer. Geol. 19:367.

(37) **Schuchert, Charles.** Synopsis of American Fossil Brachiopoda. Bull. U. S. Geol. Surv. 87.

(38) **Ulrich, E. O.** The Lower Silurian Lamellibranchiata of Minnesota; The Lower Silurian Ostracoda. Geol. Minn. v. 3, pt 2.

(39) **Ulrich, E. O., & Scofield, W. H.** The Lower Silurian Gastropoda, ibidem.

(40) 1898 **Whitfield, R. P., & Hovey, E. O.** Catalogue of the Types and Figured Specimens in the Paleontological Collections of the Geological Department, American Museum of Natural History, Bul. Amer. Mus. Nat. Hist. 11:1.

(41) 1899 **White, T. G.** Report on the Relations of the Ordovician and Eo-Silurian Rocks in Portions of Herkimer, Oneida and Lewis Counties. N. Y. State Mus. Rep't 51 (for 1897), p. 21.

(42) **Prosser, C. S.** Sections of the Formations along the Northern End of the Helderberg Plateau. N. Y. State Geol. Rep't 18 (for 1898), p. 51.

(43) **Jaekel, Otto.** Stammesgeschichte der Pelmatozoen. v. 1.

(44) 1900 **Cumings, E. R.** Lower Silurian System of Eastern Montgomery County, N. Y. N. Y. State Mus. Bul. 34, p. 415.

(45) 1900 **Prosser, C. S.** Notes on Stratigraphy of Mohawk Valley and Saratoga County. N. Y. State Mus. Bul. 34, p. 469.

(46) 1901 **Bather, F. A.** The Geologic Distribution of Pollicipes and Scalpellum. Science, n. s. 14:112.

(47) **Ruedemann, Rudolf.** Hudson River Beds near Albany and Their Taxonomic Equivalents. N. Y. State Mus. Bul. 42.

(48) **Ruedemann, R.** Trenton Conglomerate of Rysedorph Hill and Its Fauna. N. Y. State Mus. Bul. 49, p. 3.

(49) 1902 **Nickles, J. M.** The Geology of Cincinnati. Jour. Cinc. Soc. of Natural History. 20:49.

(50) **Pocta, Phil.** Ueber die Anfangskammer der Gattung Orthoceras Breyn. Sitzungsber. der K. böhm. Gesellsch. d. Wiss.

(51) **Ulrich, E. O., & Schuchert, Charles.** Palaeozoic Seas and Barriers in Eastern North America. N. Y. State Mus. Bul. 52, p. 633.

(52) 1903 **Clarke, J. M.** Classification of New York Series of Geologic Formations. N. Y. State Mus. Handbook 19.

(53) **Weller, Stuart.** The Paleozoic Faunas of New Jersey. Geol. Surv. of New Jersey, Rep't on Pal., v. 3.

(54) 1905 **Cushing, H. P.** Geology of the Northern Adirondack Region. N. Y. State Mus. Bul. 95.

(55) **Cushing, H. P.** Geology of the Vicinity of Little Falls, Herkimer County. N. Y. State Mus. Bul. 77.

(56) 1906 **Grabau, A. W.** Geology and Paleontology of the Schoharie Valley. N. Y. State Mus. Bul. 92.

(57) 1908 **Cumings, E. R.** The Stratigraphy and Paleontology of the Ordovician Rocks of Indiana. 32d Annual Rep't of the Dep't of Geology of Indiana.

(58) **Elles, G. L., & Wood, E. M. R.** Monograph of British Graptolites; ed. by C. Lapworth. Pt VI. Pal. Soc. for 1907; pt VII, 1908.

(59) **Kümmel, H. B.** Paleozoic Sedimentary Rocks in Franklin Furnace Folio, N. J.; U. S. G. S., Folio 161.

(60) **Ruedemann, Rudolf.** Graptolites of New York, pt 2. N. Y. State Mus. Mem. 11.

(61) 1909 **Stose, George W.** Mercersburg-Chambersburg Folio, Pa.; U. S. G. S. Folio 170.

(62) **Bassler, Ray S.** The Cement Resources of Virginia West of the Blue Ridge. Virg. Geol. Surv. Bul. 2.

(63) **Foerste, Aug. F.** Preliminary Notes on Cincinnatian and Lexington Fossils. Bul. Denison Univ. 14:289.

(64) **Miller, W. J.** Geology of the Remsen Quadrangle. N. Y. State Mus. Bul. 126.

(65) **Grabau, A. W.** Physical and Faunal Evolution of North America during Ordovicic, Siluric and Early Devonic Time. Jour. of Geol. 17:231.

(66) 1910 **Miller, W. J.** Geology of the Port Leyden Quadrangle, Lewis County, N. Y. N. Y. State Mus. Bul. 135.

(67) **Schuchert, C.** Paleogeography of North America. Bul. Geol. Soc. Amer., v. 20.

(68) 1911 **Ulrich, E. O.** Revision of the Paleozoic Systems, pts 1–3. Geol. Soc. Amer. Bul. v. 22, no. 3.

PALEONTOLOGICAL NOTES

Sphenophycus nom. prop.

The work in the Schenectady shales has brought to light a great quantity of finely preserved algal remains. In part these are identical with Sphenothallus latifolius, described by Hall from the top beds of the formation at Schoharie, but the greater part represents one or more different species, and many exhibit important features not shown by the original material. We should not have undertaken to describe these if we had not had the authoritative advice and encouragement of Mr David White regarding them, but we should have much preferred if Mr White would himself have agreed to write a note on these Lower Siluric algae.

Hall (title 3, p. 261) described the genus Sphenothallus as follows: " Plant consisting of a stem, with diverging wedge-form leaves, or of detached leaves having this form. Leaves apparently succulent or thickened, and sometimes subcoriaceous." He cites two species as belonging to it, viz, Sphenothallus angustifolius and S. latifolius. The former has been found by us as a rather frequent fossil in the Utica shale of Dolgeville and elsewhere and on reinvestigation (1897, N. Y. State Geol. Rep't 15) was referred to as a " sessile Conularia." The stem of the type specimen was found to be a cephalopod shell, to which the " leaves " are attached by basal disks. While we no longer consider this species as properly belonging to the genus Conularia itself, there is no doubt in our minds of its taxonomic position with the Conularidae. It therefore can not be retained in the same genus with the other species, S. latifolius, if the latter is an alga, and the question arises which of the two should retain the generic name Sphenothallus. S. angustifolius is the first species described under the diagnosis and moreover the latter is clearly shaped principally after this species. If, therefore, S. angustifolius is a conularid, but not congeneric with Conularia, it should retain the generic name and a new one be selected for the second species. We therefore propose here the name *Sphenophycus* for the second species.

Both Sphenothallus angustifolius and Sphenophycus latifolius possess remarkably thick carbonaceous tests. That of Sphenothallus angustifolius also contains phosphate of lime and has the appearance of having originated from a chitinous or conchiolinous substance. Following a suggestion of Mr White, I tested the organic matter of Sphenophycus by fire and found that it burns with a fair degree of completeness, leaving an ash residue consisting of clay and silica and probably resulting from silt infiltration into the canals of the organism. This evidence suggests the vegetable nature of the carbonaceous tests.

The most remarkable portions of these vegetable remains are the club-shaped bodies reproduced on plate 2, figures 1–13. These were all obtained in one block that had fallen from the cliff overhanging the Mohawk river at Aqueduct. They consist of an elliptical or circular distal smooth body borne on an equally smooth pedicel. The distal body is in well-preserved specimens flattened at the apex and in some this part is infolded. The wrinkles and partial sections prove that the distal bodies were originally more or less inflated and the pedicel tubular (see section, plate 2, figure 8). The outline of these problematic fossils, a large number of which were obtained from the block, proved suggestive of a variety of animal objects, notably of chimaeroid, gastropod and cephalopod egg-cases, all of which suggestions were disproved by the kind advice of Messrs Bashford Dean, Gratacap and Pilsbry. Mr White has expressed the opinion to us that these bodies are algal flotation appendages. A specimen was observed showing these bladders attached to a spirally arranged group of the thalli of a Sphenophycus. It broke when lifted up; the portion saved is reproduced on plate 2, figure 13. This specimen and the apparent absence of any apertures of the bulbs or of any substance originally inclosed within them, are strong arguments in favor of that view. Likewise, the absence of any coarser surface sculpture on the bulbs, the extreme length of the pedicels in some and its unvaryingly torn proximal extremity, as well as the fibrous character of the pedicel seen in some examples, and the auxiliary bulblike inflations (see plate 2, figure 11) in the pedicel, point to the vegetable origin of these fossils and their character of flotation appendages. We are not sure yet to which of the two species here distinguished they belong, although the present evidence indicates that they are referable to S. latifolius.

Several specimens of S. latifolius appear at first glance lobate (see plate 1, figure 1). It has been pointed out to me by Mr White that this appearance is due to the presence of cuplike marginal cavities and that these are apparently connected with the neural system which is canalicular. These cups and the canals are well seen in plate 1, figure 2.

Besides the genotype, S. latifolius, which according to the original description possesses "broadly cuneate thalli,[1]" we have distinguished a second species, but there are probably more than two species present, as indicated by such thalli as those reproduced in plate 1, figure 9. The cuneate thalli of S. latifolius were probably arranged spirally around a stem, as indicated by their wedgelike shape and by the specimen plate 1, figure 13.

The largest thalli found are those typically represented by plate 1, figure 5. While also possessing a broadly cuneate to trapezoidal outline, they are not single as those of S. latifolius, but, as again pointed out to us by Mr White, "composed of rather slender, but rigid conical thalli, originating at the scarlike pits or depressions of the lower parts of the axis."

A third type is represented by plate 1, figure 9. Only one specimen of this interesting form has been thus far obtained. It shows a pitted middle axis from which proceed lobate thalli, ornamented with broadly recurving lines. This material we consider too imperfect for specific differentiation.

Cyathodictya ? tubularis nov.

Certain layers of the Canajoharie beds at Canajoharie are covered with multitudes of small elongate bodies which contrast by their brown coloring with the black shale. These bodies are mostly about 5 mm long and then regularly conical in outline, but reach as much as 15 mm in length and these larger specimens are cylindrical in outline. While completely flattened out, the roundish aperture at one end and the thickened lateral margins demonstrate that the bodies were originally tubular and rather thick-walled. The proximal end fades out in most specimens; in many others it is jagged as if broken off and in a few it contracts to a blunt point. The long tubular specimens show no appreciable contraction at either end.

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[1] The original description is: "Leaves broadly cuneate, somewhat thickened at the outer margin, and truncate at the lower extremity; surface obscurely striated. The specimens are often marked on one side by a ridge or midrib along the center, and sometimes transversely wrinkled. These leaves all appear to have been thick and succulent, like the Fuci."

Fig. 8

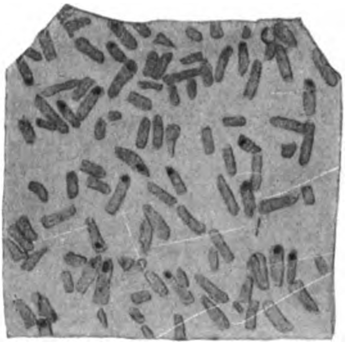

Fig. 9

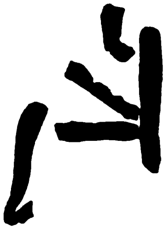

Fig. 12

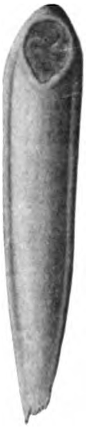

Fig. 11

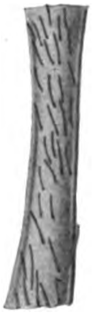

Fig. 10

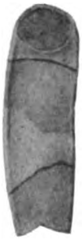

Fig. 8–12. Cyathodictya ? tubularis nov.

Fig. 8. Group of specimens of usual size. Natural size. Fig. 9. Group of large specimens. Natural size. Fig. 10. Specimen showing aperture, x 5. Fig. 11. Specimen showing spicules, x 5. Fig. 12. Fairly perfect specimen. Type, x 5.

Canajoharie shale at Canajoharie, N. Y.

The substance of the fossil is preserved and this as well as the thick margins show the walls to have been quite substantial.

We have referred this gregarious organism with doubt to Cyathodictya largely on account of the form and thick walls of the bodies. Owing to their small size we have not been able to satisfy ourselves as to the presence of spicules although delicate lines suggesting these are seen in some places on the walls, the longitudinal spicules being more distinct in some, the transverse in others. Larger dictyonine spicules (typical hexactines), corresponding in size to those of the Utica species C. reticulata (Walcott) have been found in adjoining layers, demonstrating the actual presence of dictyosponges in these beds.

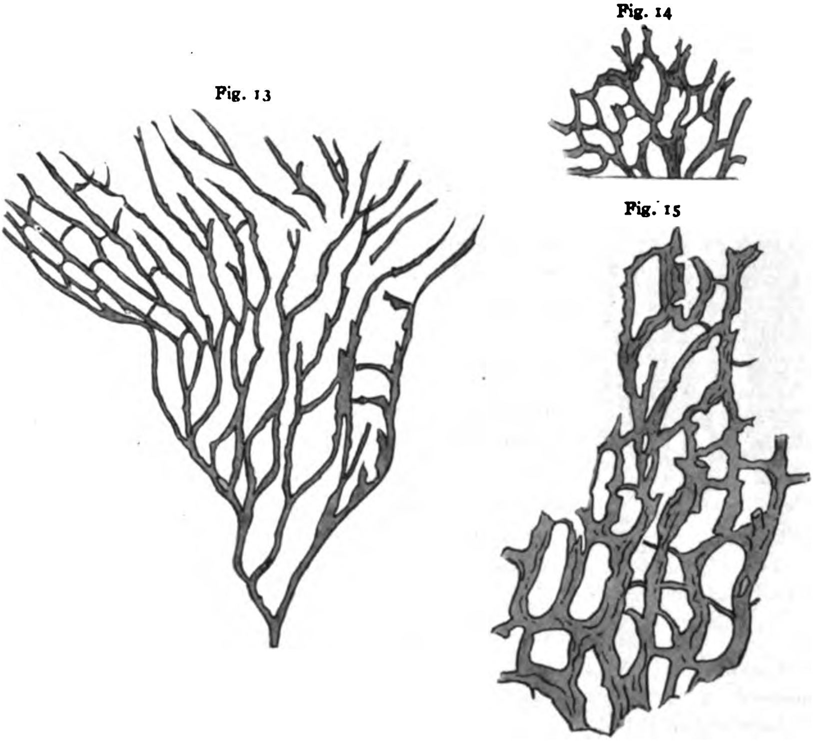

Fig. 13–15. Dictyonema arbuscula (Ulrich)

Fig. 13. Small rhabdosome, x 5. Fig. 14, 15. Fragments of distal portions of larger rhabdosomes, x 5.
Indian Ladder beds, at the Indian Ladder, N. Y.

Dictyonema arbuscula (Ulrich)

Pl. 2, fig. 15

A small Dictyonema was found to be not infrequent in the Indian Ladder shale at the Indian Ladder, which proved to be identical with a species hitherto recorded only from the Eden (formerly Utica) shale of the neighborhood of Cincinnati. According to Doctor Ulrich this species occurs in the Middle Third of the Eden shale. It was first described and figured in 1879 (title 8, p. 28) and also noted in the Graptolites of New York, part 2 (title 60, p. 151). Like other Dictyonemas this species also shows a tendency to undulating, alternatingly adnascing branches in the proximal portion, giving that part a Desmograptuslike aspect, while it is a typical Dictyonema in the distal portions (see text fig. 13).

Dictyonema multiramosum nov.

Pl. 2, fig. 16

Description. Rhabdosome of small size (32 mm high) apparently cyathiform, arising from a short thick stem. Branches extremely thin and closely arranged, about .5 mm apart and .2 mm wide, bifurcating at frequent intervals, slightly undulating; mostly of rather straight appearance, frequently coalescing where brought in contact by the wavy form of the branches, or where the latter are straight, with thin dissepiments in long intervals. Thecae not clearly seen.

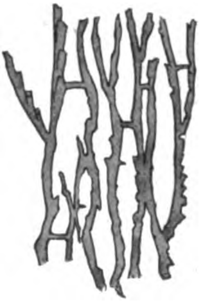

Fig. 16. Dictyonema multiramosum nov.

Portion of rhabdosome, x 5.

Schenectady beds, Rotterdam Junction, N. Y.

Horizon and locality. Schenectady beds near Rotterdam Junction, N. Y.

Remarks. But a single specimen of this species was obtained and this being inclosed in a sandy shale, is far from perfect in preservation. It is therefore possible that the species should be rather referred to Desmograptus which it approaches in some portions of the frond.

We have not observed any species in either the Trenton or Utica shales which approaches D. multiramosum in the extreme delicateness of the rhabdosome.

Dicranograptus nicholsoni Hopkinson var. **parvulus** nov.

The Canajoharie shale at Morphy's creek near Pattersonville, N. Y., contains in its basal layers, within a few feet of the underlying Glens Falls limestone a diminutive form of Dicranograptus nicholsoni which deserves recognition as a variety, as all the specimens of this bed retain uniformly their peculiar character.

The main differences from the typical nicholsoni are the closer arrangement or smaller size of the thecae, which number 14 in 10 mm, and the greatly varying length of the biserial portion (4–11 mm). The form of the thecae does not seem to differ from that of the larger types. The biserial portion has been seen in only one specimen and in this the axillary angle is smaller than in nicholsoni typus, namely about 10°.

The width of the stipe is not materially different from that of nicholsoni.

The most remarkable feature of the specimen retaining the biserial portion is the continuation of the axes of the biserial branches in antisicular direction. These axes have to our knowledge not been observed in either Dicellograptus or Dicranograptus outside of the theciferous portion. The free portions are too long and delicate to have been theciferous and to have secondarily become separated from the thecae. The rhabdosome of Dicranograptus was hence suspended from two axes which, as the parallel and slightly convergent final direction of the axes suggests, proceeded from a common initial point.

The specimen exhibits also a large " web " between the branches.

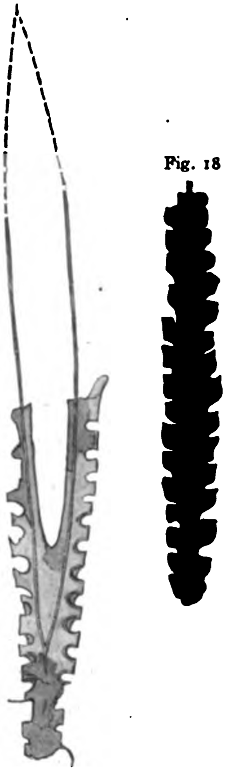

Fig. 17, 18. Dicranograptus nicholsoni Hopkinson var. parvulus nov.

Fig. 17. Specimen showing axes or nemacauli, x 5. Fig. 18. Long biserial portion of specimen showing form of thecae, x 5.

Canajoharie shale, Morphy creek, N. Y.

Dicellograptus nicholsoni possesses in the slate belt of New York a much larger *vertical range* than we had inferred in Memoir 11, page 318. We had cited it there from the "Trenton shales" (Normanskill shale) in several varieties and in typical development from the Utica of South Trenton, the Mohawk valley and the shales at Saratoga lake, which were also supposed to be of Utica age. The shales which carry D. nicholsoni in the Mohawk valley are in the present paper referred to the Trenton as Canajoharie shale and those at Saratoga lake are also correlated with the Trenton as Snake Hill beds. The Normanskill shale is now considered as being as old as the Chazy formation. We have also found a specimen in the Indian Ladder beds. This species ranges therefore in the shales of Eastern New York from the Chazyformation to the top of the Lower Siluric.

Diplograptus (Mesograptus) putillus Hall

Hall originally described as Graptolithus putillus in the Canadian Organic Remains, decade 2, a small graptolite from the "Hudson River group" of Iowa, that afterward was found to range through the Eden beds of Ohio (title 49, page 68) and to occur in many localities in the Utica shale of New York (title 60, page 416). Our subsequent work has shown that this minute type ranges in several mutations which are especially characterized by different size, from the Normanskill shale through the Snake Hill beds, the Canajoharie shale into the Utica shale. One of these (from the Normanskill shale) has been distinguished before as Climacograptus putillus mut. eximius (op. cit. page 420). Also the mutation of the true Utica horizon is distinguished by extremely small size, while those of the Canajoharie and especially the Snake Hill beds are remarkable for their greater size. It must be these larger mutations which characterize in Sweden a zone below that of Diplograptus quadrimucronatus.

The species has been currently referred to Diplograptus, while the present writer placed it in the Graptolites of New York with Climacograptus on account of the frequent Climacograptus aspect of the rhabdosomes. Part 6 of the "British graptolites" by Lapworth, Elles and Wood (title 58, page 256), proposes the subgenus Mesograptus for "forms in which the appearances presented are in part those characteristic of a typical Diplograptus (Orthograptus) and in part those more characteristic of a typical Climacograptus." It would seem that the subgenus Glyptograptus also contains forms quite similar to our species.

Diplograptus (Mesograptus) mohawkensis nov.

Pl. 2, figs. 18, 19

Diplograptus foliaceus (in part) *auctorum.*

Rhabdosome small, about 15–22 mm in length and 1.5–2 mm in width; the latter rapidly attained (in about 3 mm), in the largest specimen again narrowing in antisicular direction. The sicula has not been observed; the virgella is stout and 1.5 mm long. Thecae 12–14 in 10 mm; having the Climacograptus aspect in both views in the proximal narrowed portion and throughout in the obverse aspect, and the Diplograptus aspect in the reverse aspect; having an average length of 1.5 mm and overlapping one-half of their length. The first thecae are narrow and with their outer walls but slightly inclined to the axis, the later thecae have oblique straight ventral margins in the reverse aspect and sigmoidal ventral margins in the obverse aspect. The excavation in the latter aspect is fairly deep (one-fourth the width of the rhabdosome); the apertural margin nearly straight.

Horizon and localities. In the lowest part of the Canajoharie shale at Morphy's and Swartztown creeks near Amsterdam, N. Y., and at the Carlsbad spring near Saratoga, N. Y.

Remarks. This species is one of the various forms that have been referred in our shales first to Diplograptus pristis Hall, and later to D. foliaceus Murchison; but it is readily distinguished from the rest by the striking difference in the two aspects, the obverse which is that of a Climacograptus, and the reverse which is that of a Diplograptus. In the Monograph of the British Graptolites the subgenus Mesograptus is proposed for that group of Diplograpti in which the stipe is conspicuously concavo-convex in section and the appearance of the thecae different in the two aspects. In the second of the two groups again distinguished under the Mesograpti, the excavations of the Climacograptus aspect are deep and conspicuous throughout. This condition, for which the subgenus Amplexograptus is proposed, is approached, if not reached, by the present form, although the excavations are not as deep as in the typical Amplexograpti.

Fig. 19 Fig. 20

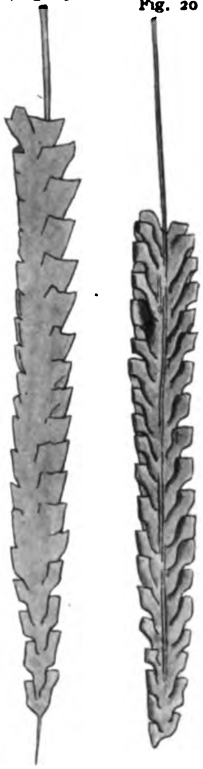

Fig. 19, 20. Diplograptus (Mesograptus) mohawkensis nov.

Fig. 19. Reverse aspect, x 5. Swartztown creek, N. Y.

Fig. 20. Obverse aspect, x 5. Carlsbad Spring near Saratoga, N. Y.

The species occurs almost to the exclusion of others and in profuse numbers in the basal beds at Swartztown creek and Morphy's creek and is quite obviously characteristic of the lowest zone of the

Canajoharie beds. It reaches there but 15 mm in length, and appears to have possessed a rather tenuous periderm. At the Carlsbad spring the specimens reach a greater size. From the geographic position of these latter shales near the Glens Falls belt of Rowland mills, we infer that these shales also lie near the base of the Canajoharie beds.

From the typical Diplograptus (Mesograptus) foliaceus this species is distinguished by its smaller size, narrower sicular portion and the stronger sigmoidal curvature of the ventral walls of the thecae in the obverse aspect. It does not seem, however, to be nearer related to any of the other British Lower Siluric Diplograpti.

Diplograptus (Amplexograptus) macer nov.

Pl. 2, figs. 20, 21

Description. Rhabdosome slender, 20–25 mm long with a maximal width of 1.5 mm, which is very gradually attained. Sicula not observed. Virgella small and inconspicuous. Thecae 12–14 in 10 mm, about 1.5 mm long, inclined 10°–12°, overlapping about one-half their length, with fairly straight or slightly sigmoidal ventral and straight to slightly concave apertural margins on the reverse aspect and straight vertical ventral margins and deep (one-third the width of rhabdosome) apertural excavations on the obverse aspect.

Horizon and locality. The top beds of the Canajoharie shale in the Minaville section are characterized by this species.

Remarks. D. macer is easily distinguished from the other Diplograpti of the " Utica " shale by its narrow, slender form, the closely arranged thecae and the very different appearance of the two sides; the rather deeply notched obverse aspect being especially easy of recognition. This aspect characterizes the species as falling within the subgenus Amplexograptus of Diplograptus. It would seem to be a further development of that of the earlier D. mohawkensis.

This species is in many features very similar to D. (Amplexograptus) arctus Elles & Wood, an earlier British form of the Dicranograptus shales, and is possibly a later mutation of the latter. The principal distinguishing features are the larger size and the long virgella of D. arctus.

Diplograptus vespertinus Ruedemann

In the Graptolites of New York, Memoir 11, page 352, the author has distinguished a form as mut. vespertinus of Diplograptus foliaceus Murchison, occurring typically in the "Utica shale" of the Mohawk valley and Hudson valley, and the Lorraine beds. More recent work in these shales has shown that

Fig. 21

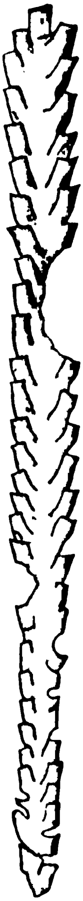

Fig. 22

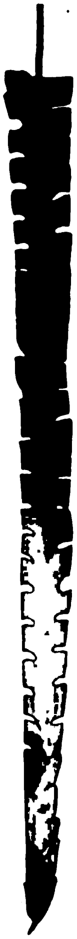

Fig. 23

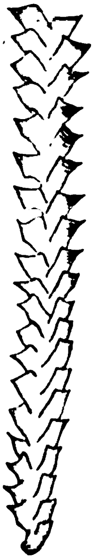

Fig. 21, 22. Diplograptus (Amplexograptus) macer nov.
Fig. 21. Reverse aspect. Fig. 22. Obverse aspect. Both x 5.
Canajoharie shale, Minaville, N. Y.

Fig. 23. Diplograptus peosta Hall.
Specimen from Indian Ladder beds at the Indian Ladder, N. Y. x 5.

it will be necessary to distinguish these Diplograpti more sharply if they are to be of any use in the elaboration of the stratigraphy of the shales. We therefore for the present restrict vespertinus to the forms from the Canajoharie shale. Since Diplograptus foliaceus Murchison, as since emended by Elles & Wood, clearly represents a different type, we recognize D. vespertinus as a distinct species.

Climacograptus spiniferus Ruedemann

We comprise under this name the form which in the Graptolites of New York, part 2, page 411, had been described as C. typicalis mut. spinifer from the shales at Ballston, Saratoga and Bakers Falls (now Hudson Falls). This type is a common and characteristic graptolite of the Canajoharie shale where C. typicalis is absent; it also occurs in the Snake Hill shale and enters into the Schenectady beds. It is therefore in its range, as also in its characters, so very distinct from C. typicalis that it should be recognized as a different species. I learn from Doctor Ulrich that it also is a characteristic graptolite of a part of the Martinsburg shale. The Mohawkian mutations of C. bicornis (a Normanskill species) that have been cited by several authors, the present included, probably all belong to spiniferus.

Lasiograptus (Thysanograptus) eucharis (Hall)

This minute form, which is remarkable for the frequent occurrence of entire colonies or synrhabdosomes, was originally described by Hall as a Retiograptus, later, on account of the form of the thecae, referred by the present writer to Diplograptus and in the Graptolites of New York, part 2, page 397, brought with doubt under Glossograptus. Last summer's investigation of the shales of the Mohawk valley has afforded the writer a few specimens from the Canajoharie shale of the Chuctenunda section and the Schenectady shale of Schenectady, which at last establish the generic position of this species. While those from the Chuctenunda reveal the marginal lacework characteristic of Lasiograptus, the specimens from Schenectady are partly pyritized and retain the fibrous thickenings of the angles of the thecal walls (see text figure 24).

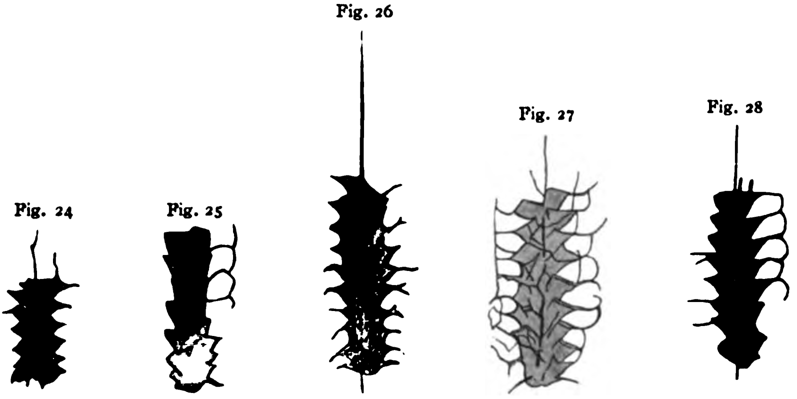
Fig. 24 Fig. 25 Fig. 26 Fig. 27 Fig. 28

Fig. 24–28. Lasiograptus (Thysanograptus) eucharis (Hall).

Fig. 24. Pyrityzed specimen showing fibrous thickenings of the margins. Fig. 25. Specimen showing traces of the extra marginal lacework (lacinia). Fig. 26. Specimen showing pyritized marginal thickenings and ventral processes. Fig. 27. Specimen with fairly complete lacinia. Fig. 28. Specimen with a different aspect of the lacinia. All x 5.

Originals of Figs. 24 and 26 from Schenectady beds of Dettbarn quarry near Schenectady, N. Y.; those of Figs. 25, 27, 28 from Canajoharie shale Chuctenunda creek near Amsterdam, N. Y.

The genus Lasiograptus has been extended by Elles and Wood in their splendid Monograph of the British Graptolites (title 58, page 318), and several subgenera distinguished. Our species would correspond to their subgenus Thysanograptus in which the thecae are of the typical Amplexograptus form, and the ventral processes unite to form a complete ventral lacinia. In its general dimensions L. eucharis resembles the British L. harknessi Nicholson; it is, however, distinguished by the closer arrangement of the thecae.

In the Monograph of the Graptolites of New York, volume 2, L. eucharis is cited as occurring in the Utica shale and the "Trenton-Utica transition beds" of Panton, Vt. In our work, carried on since the publication of that volume, we have found that species also in the Snake Hill and Canajoharie shales which are of Trenton age and in the Frankfort shale, so that the range of L. eucharis is found to extend both below and above the Utica shale.

Glyptocrinus sp.

The presence of a species of Glyptocrinus in the Snake Hill sandstone is proven by a calyx and numerous stems with the characteristic alternation of larger and smaller joints. The calyx was about the size of that of G. decadactylus and while distinctly showing the numerous interbrachials of Glyptocrinus, it is not well enough preserved for close determination.

Heterocrinus ? gracilis Hall

Pl. 3, fig. 5

Hall (title 3, page 280, plate 74, figure 3) describes and figures as Heterocrinus ? gracilis an extremely small, slender crinoid, of which he states that " it occurs in the soft olive shale at Snake hill, Saratoga county, N. Y." Since Hall was unable to make out the arrangement of the calyx-plates, the species can not be considered as properly defined. It is, however, obvious to the collector that the shale, and especially a thin, dark gray sandstone bed at Snake hill, contains this and other coarser crinoids in considerable number. Unfortunately we have been unable thus far to obtain satisfactory material. We figure here a specimen of H. ? gracilis which permits a view of a part of the calyx, but defer the generic determination of this minute crinoid until better material has been obtained.

Cremacrinus sp.

Doctor Ulrich has kindly directed my attention to the presence of a specimen of Cremacrinus in the shaly Snake Hill sandstone. The specimen probably represents a new species since the calyx and whole body are more slender than the other congeneric forms; but we do not feel warranted, with the incomplete material before us, to do more at present than note the presence of this genus in the Snake Hill beds.

Carabocrinus cf. **radiatus** Billings

Pl. 3, fig. 6

The citation of this species among the Snake Hill fossils is based upon a single calyx plate which well exhibits the characteristic angular radiating sculpture lines of that species and corresponds to the basals (subradials) in outline. C. radiatus is known from the Trenton limestone of Ottawa.

Edrioaster saratogensis nov.

Pl. 3, figs. 2–4

Body of small size, about 14 mm in diameter, discoid, gently convex on the oral side; aboral surface not seen; apparently not attached.

Thecal plates irregular polygonal, mosaic, disposed without order and of small number; their surface granulose. Usually three or four large plates in the interambulacra, the marginal plates not seen.

Rays five, four solar and one contrasolar, broad and nearly straight in the proximal half, the extremital part rather abruptly bent and terminating within the disk subparallel to the margin. Oral aperture elongate, two rays arising from one, and three from the other end, surrounded by (five?) triangular oral plates with raised lateral edges. Ambulacra covered by two rows of alternating, inwardly converging, contiguous narrow plates with flat, horizontally extended tops. Subambulacral plates polygonal, as the thecal plates, but smaller, apparently hexagonal (the outer margins not clearly seen). Cover plates granulose, as the thecal plates. Anal pyramid small, consisting of four triangular plates, situated as in Agelacrinites, between the distally approaching or overlapping pair of solar and contrasolar rays.

Horizon and locality. Snake Hill shale and sandstone at Snake hill, Saratoga county, N. Y.

Remarks. This small and interesting type occurs only in molds in graywacke sandstone, which has been found loose in slabs under the cliff on the shore of the lake but not in place. Altogether four specimens were obtained by me.

The species is clearly congeneric with E. bigsbyi Billings, from the Trenton of Ottawa. It agrees exactly with that species, and since the latter is the type of the genus, also with the genus, in the form of the ambulacra and their coverplates, the form of the tegal plates and their sculpture. The oral and ambulacral plates, as well as the anal pyramid of Edrioaster bigsbyi have not yet been described and it is therefore still possible that they differ in the genotype, and the reference of our species to Edrioaster is doubtful in that respect.

Billings described E. bigsbyi as possessing four rows of pores in the ambulacra. Jaekel (title 43, page 44) has pointed out that these pores, if they existed, had probably nothing to do with the pores of the Cystoidea, but only served for the entrance of water into the vectacle furrows or for the discharge of sexual products. In E. saratogensis the cover plates fit snugly against each other wherever well preserved and have straight lateral sides, leaving no room for pores. In a few places, however, where the plates are apparently somewhat abraded, they are contracted in the middle, leaving long elliptic depressions between them.

Jaekel refers a second species, E. buchianus Forbes sp. (from Bather's ms.) to Edrioaster, basing his generic description on both forms. He describes the body as spherical from the cast of E. buchianus. E. saratogensis appears as a low spherical segment, but there is evidence of a flattening of the body in the pushing of plates over each other, and since the underside is not preserved in our material, it is possible that E. saratogensis also was originally spherical.

The direction of the spiral course of the ambulacra was in E. saratogensis apparently already fixed in distinction to E. bigsbyi, where it could be solar or contrasolar; and it has already reached the condition of the ambulacral rays of Agelacrinites.

The anal pyramid of E. buchianus is, according to Bather, surrounded by irregular plates. Also in this character E. saratogensis would seem to have advanced somewhat in showing a regular pyramid.

We have seen nothing that could be recognized as a madreporite.

All three known species of Edrioaster are of approximately the same age.

Taeniaster schohariae nov.

Pl. 3, fig. 1

This interesting species of Paleozoic Ophiuroidae or brittle stars, is based on a single individual, retaining three arms, one of which presents the ventral view and the other two their lateral views, resp. sections. The specimen is small, the arms about 15 mm long, and it is without a disk. The arms are slender and flexible, about 1.3 mm wide at the base, and almost as high in lateral view, originally probably cylindrical. The ventral view shows a straight or slightly zig-zagged ambulacral canal, and on both sides of this squarish depressions surrounded by the ambulacral and adambulacral ossicles, the covering lower arm plates not being retained if they existed. The inner (ambulacral or vertebral) ossicles appear as narrow and outwardly curved ridges, the outer or adambulacral ossicles as ridges bent in the opposite direction with a projection in the middle of the outer arch. The ambulacral ossicles are not directly opposite nor regularly alternating, but those of the right side on the ventral view advanced about one-third the length of the ossicles beyond those of the other side.

The lateral view of one other arm exhibits the ossicles as vertical bars, that are thickened at both ends resembling vertebrae and terminating at the dorsal side with a flat surface and forming there an apparently continuous layer. They appear almost twice as wide as the intervening spaces. The dorsal surface bears bundles of obliquely forward directed spines, one bundle corresponding to each ossicle. These spines appear in the right arm to proceed from small spine-bearing plates attached to the adambulacrals, as in the closely related Bundenbachia. On one arm two bundles are seen to proceed from each segment, one oblique, the other vertical to the arm. The oral skeleton consists of stout, bifid pieces, much resembling the oral pairs of adambulacrals of the genotype.

Horizon and locality. Upper Schenectady beds near Schoharie Junction, Schoharie county, N. Y.

Remarks. The genus Taeniaster was founded by Billings (title 4, page 80) on the Trenton species T. spinosus and T. cylindricus. The latter of these species has been made the type of the new genus Taeniura by Gregory (title 31, page 1035); Parks[1] however has pointed out that from inspection of Billings's type specimen he would rather refer the species to Lapworthura, Gregory. However that may be, we will consider here the genus Taeniaster as represented only by T. spinosus and T. elegans Miller. In that case our specimen would show the same general form and arrangement of the ossicles as both these species, but differ from both by its more slender arms. The shape of the ossicles resembles especially those of Taeniaster elegans, as figured by Miller,[2] but we presume that Miller's figure is somewhat diagrammatic. Parks states that T. elegans would seem to be a true Protaster, but for the fact that no disk is present. The same would be probably true of our species, for Parks's figure 4, giving the ventral view of an arm, presents a picture well comparable to the view of our middle arm, in the shape and arrangement of the ossicles, with the difference that the latter in our specimen appear much thinner.

There is no evidence observable in our specimen of any other plates but the so-called vertebral ossicles with the possible exception of the spine-bearing ossicles; it is therefore probable that T. schohariae possessed only this interior skeleton and no covering plates, a feature which is claimed by Stürtz (title 16,

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[1] Canadian Institute, Trans. 1907-8, 8: 371.

[2] Jour. Cinc. Soc. Nat. Hist. v. 5, 1882, pl. 1, fig. 6.

p. 234) for the whole suborder Ophio-encrinasteriae. Gregory, however, states that the true Taeniaster is asteroid in oral armature, in its alternately arranged ambulacral ossicles and in the absence of a disk.

Stürtz, *ibidem,* points out that Taeniaster and Bundenbachia exhibit a flexibility of the arms vertically to the disk which is among recent ophiurans found only in Ophiotholia. Our specimen is also preserved in a lateral view showing the same peculiar position of the arms.

Paleschara ulrichi nov.

Zoarium incrusting or parasitic mostly upon cephalopod shells, covering the entire surface, consisting of relatively large oblong polygonal (mostly irregularly pentagonal or hexagonal) cells (9 to 12 in space of 10 mm) with thin, low walls.

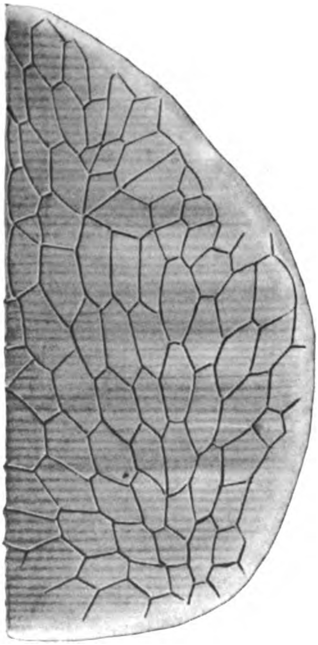

Fig. 29. Paleschara ulrichi nov.

Portion of zoarium, x 10. From Snake Hill beds at Snake hill, Saratoga county, N. Y.

Doctor Ulrich informs me that this species has larger and less regularly arranged cells than are found in its chronologically nearest relatives. Paleschara occurs in the Helderbergian, Niagaran, Richmondian and rarely in the Eden. With this species its range is extended downward to early Trenton.

Position and locality. Snake Hill beds, Snake hill, N. Y.

Remarks. This bryozoan forms a network so delicate that it is just barely visible with the naked eye. The cells are all longer than wide and form a continuous layer on the shell; they radiate from a number of starting points, being apparently composed of different confluent colonies. The corners of the cells are mostly slightly thickened and in some places elevated into distinct tubercles.

Spatiopora sp.

The compressed cephalopod shells in the Utica and Canajoharie shales are very frequently covered by a parasitic bryozoan growth which has in former papers been referred by the present writer to

Sagenella ambigua Walcott. According to information from Doctor Ulrich, these growths represent one or more species of Spatiopora, Sagenella ambigua being one of them. A different incrustation on a cephalopod from the Snake Hill beds is above described as Paleschara ulrichi.

Lingula rectilateralis Emmons

Pl. 4, fig. 1

This species which was originally identified by Hall with L. quadrata Eichwald occurs in good specimens in the Schenectady beds at the Dettbarn quarry at Schenectady and at Rexford Flats. Hall cited the species only from the middle and upper Trenton, but according to Schuchert it ranges from the Trenton into the Lorraine.

Orbiculoidea tenuistriata (Ulrich)

Pl. 4, fig. 2

A single specimen of this species was found at the top of the Frankfort shale in the Frankfort gulf. It has been identified by Doctor Ulrich with his species described in 1878 (Jour. Cin. Soc. Nat. Hist. I, p. 96, pl. 4, fig. 10) from beds of Covington, Ky., that are now referred to the middle part of the Eden group of the Cincinnati region.

Plectambonites sericeus (Sowerby) **typus**

Pl. 4, fig. 3-6

The Snake Hill shale at Snake hill contains a possible but local variety of Pl. sericeus which markedly differs from the currently accepted expression of this extremely variable species in possessing a well-defined mesial fold on the pedicel valve and a corresponding sinus on the brachial valve, as shown in the specimens here reproduced. In other features, notably the general outline and surface sculpture, the specimens do not appear to differ from the general aspect of the species. While we have found this feature neither figured nor described of any of the American representatives of the species, Sowerby's original figures in "Siluric System" exhibit the same outline and relative size as our Snake Hill variety and clearly also suggest the presence of the mesial fold. Since Sowerby's types were from the Caradoc of Shropshire, they may be of the same age and identical. For that reason we have designated this particular expression of the species as typus; should it be found, however, that the Shropshire and Snake Hill specimens are both local forms, and hence developed independently of each other, those from Snake hill would have to be distinguished by another name, (var. jugata).

Plectambonites centricarinatus nov.

Pl. 4, fig. 7

The Indian Ladder beds have afforded a rather small type of Plectambonites that is distinguished from the other members of the genus by several peculiar features. The most important of these are the presence of a fold on the pedicel and of a mesial sinus on the brachial valve, the sinus in turn bearing a sharp mesial rib; another is the prominent cardinal wrinkles. It has the mesial sinus and fold in common with a variety of P. sericeus from Snake hill. The small Indian Ladder type is no longer referable to P. sericeus as a variety, its general form being relatively longer and the valves flatter. This species, in common with P. sericeus var. asper James, from the Rysedorph Hill conglomerate (title 48, page 18) has the cardinal folds, the tendency to less unequal radiating lines than in the typical P. sericeus and also the acute cardinal angles. Doctor Ulrich has meanwhile pointed out to me that the Rysedorph Hill and James varieties are different. The Indian Ladder form is allied to the Rysedorph Hill variety by the features mentioned and to the P. sericeus from Snake hill in the mesial fold and sinus.

Plectorthis sp. cf. **whitfieldi** (N. H. Winchell)

Pl. 4, fig. 8

A single valve was obtained in the sandy shale of the Snake Hill beds at Snake hill which while agreeing in the surface sculpture with the form here described as Plaesiomys retrorsa, differs greatly in the outline and convexity of the valve. As suggested to me by Doctor Ulrich, it may possibly be the ventral valve of a Plectorthis, like P. whitfieldi (N. H. Winchell). The costae are remarkably sharp, separated by intervals of equal width; they increase twice by interplantation and number forty-six along the margin. Concentric striae are seen in the intervals. The original is an impression on a slab and the marginal parts may not be entirely preserved and hence the outline not as figured.

Plaesiomys retrorsa (Salter)

Pl. 4, fig. 9–12

The Snake Hill beds contain at Snake hill and in other localities large orthid shells, which however in the shales are always badly crushed and flattened. The gritty sandstone and conglomerate beds at Snake hill have afforded some excellently preserved specimens which are here reproduced. These latter show the characteristic features of Salter's P. retrorsa in outline and especially in the retrorsion of the umbo of the pedicel valve and the forward inclination of the cardinal area of the pedicel valve which latter feature distinguishes this species from the closely related P. porcata (see title 5, page 136). The surface sculpture corresponds to that of P. retrorsa as described by Billings (loc. cit.), Meek (title 6, page 93) and Cumings (title 57, page 902). It consists of sharp ribs (about fifty or more along the margin) that increase by intercalation on the brachial valve but are nearly straight on all parts and increase by bifurcation on the pedicel valve. Closely arranged fine concentric lines are seen in the interspaces while the ribs are smooth or but obscurely marked.

The hinge of the brachial valve which hitherto has not been observed, is reproduced in figure 10. It is not essentially different from that of P. loricata figured by Hall and Clarke (title 18, plate 5A, figure 33) and very remarkably like that of Hebertella sinuata figured *ibidem*. A larger valve (plate 4, figure 13) has the characters rather of P. porcata McCoy (see title 5, page 135) than of the closely related retrorsa. Both P. retrorsa and P. porcata occur also in the Trenton limestone at Ottawa; the appearance of these European species in the Snake Hill beds is therefore not a strange feature.

Clitambonites americanus (Whitfield)

Pl. 4, fig. 14–19

The Snake Hill beds furnished several specimens of a Clitambonites that in general aspect resembles Clitambonites diversus (Shaler). Since in the Ohio basin, however, several similar species have been distinguished, we have sent our specimens to Dr August F. Foerste of the Kentucky Geological Survey, who has kindly given us the following brief sketch of the Kentucky species:

> In Kentucky, we have three species of Clitambonites. The lowest of these occurs in the Perryville bed. This is characterized chiefly by the great number of rather fine radiating striations; and the relatively greater width of the shell, compared with Clitambonites diversus. In your specimens the striations are coarser than in these Kentucky specimens, and the shell is narrower.
>
> The second horizon occurs in the upper part of the Winchester, Cynthiana, or Catheys horizon (various names for the same set of strata). This species is not well understood. It contains radiating striae about as coarse as yours, but apparently is a smaller, shorter, broader species.
>
> The third horizon is at the base of the Eden, in what I have called the Rogers Gap division of the Eden. To this species I have given the name Clitambonites diversus-rogersensis (title 64, page 323). As far as the coarseness of the radiating striae is concerned, it appears to be about the same as in your specimens. The width of the Kentucky specimens, however, is greater. This is strikingly shown in the case of the brachial valves, in which the ratio of length to width often is as 15 or 16 to 25. In your specimen the dimensions are as 17 to 21.
>
> To me your specimens most resemble Clitambonites americanus Whitfield, an earlier form than any found in Kentucky. In fact, I do not know in what respect your specimens differ from that species.
>
> Of course, you are familiar with Clitambonites diversus. This is one of the larger species, similar to Clitambonites americanus, but with the shell much more strongly convex from beak to anterior margin. Concentric striae are much more constant and conspicuous. The bombiform convexity of the pedicel valve as a rule attracts instant attention. In those specimens of Clitambonites americanus, which I have seen, the antero-posterior curvature is more like that in your specimen.

Clitambonites americanus (Whitfield) was originally described and figured as Hemipronites americanus (title 11, page 243), but referred by Winchell and Schuchert (title

29, page 378) and Schuchert in his Synopsis of the American Fossil Brachiopoda (title 37, page 183) as a synonym to C. diversus. C. americanus was described from the upper Trenton group (Galena horizon) of Wisconsin, and Hall and Clarke (title 18, plate 15A) have figured it from the Trenton of Minnesota. A comparison of our specimens with Whitfield's original description and figures does not appear to bring out any differential characters. The pedicle valve at our disposal appears higher than the original description requires, but it is somewhat laterally compressed and moreover Hall and Clarke (title 18, plate 15A, figures 7 and 8) figure a still higher variety from the Trenton of Minnesota, later separated by Winchell and Schuchert(title 29, page 381) as var. altissima.

Whiteavesia cincta nov.

Pl. 5, fig. 1

Description. Shell small, obliquely ovate, nearly twice as high posteriorly as anteriorly; strongly convex. Hinge line apparently short, extending posteriorly one-third the distance from the beak to the posterior extremity of the shell. Outline passing almost imperceptibly from the hinge line into the oblique well-rounded posterior margin and thence into the more abruptly rounded basal extremity. Basal margin slightly convex, extending obliquely upward. Anterior end apparently short and fairly well rounded. Beak rather prominent, situated between one-fifth and one-sixth of the length of the shell from the anterior extremity; umbonal ridge broad, strongly rounded, very prominent in the upper half, where it is as high as the umbo, then rapidly declining to the posterior extremity. Surface marked by strong, broad, flat concentric folds that appear as elevated bands. On these many fine concentric lines are seen, and very fine raised radiating lines are observable on the cardinal slope. Muscular impressions not seen.

Horizon and locality. Grayish black sandy shale of Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. As Doctor Ulrich has pointed out to me, this species is allied to Whiteavesia cincinnatiensis H. & W., but much smaller and relatively shorter. It also resembles, in our view, W. subcarinata Ulrich, but is less subalate and convex.

The species is apparently rare in the Snake Hill beds, but a single specimen having been collected.

Whiteavesia cumingsi nov.

Pl. 5, fig. 2, 3

Description. Shell of the size of that of the associated W. cincta, but more oblique, thicker or more ventricose, less higher posteriorly (one-third higher than in front) and more elongate. The hinge line is slightly longer, the posterior margin more rounded, the antero-basal margin more distinctly concave, the anterior margin more sharply rounded and the anterior end longer. Beak not as prominent, situated one-fifth of the length of the shell from the anterior extremity; umbonal ridge distinct to posterior margin. Surface lacking the prominent concentric folds of W. cincta, but showing fine concentric lines and a few growth varices. Sometimes also faint postdorsal radii are seen.

Horizon and locality. Common in the olive colored shale at Snake hill, Saratoga county, N. Y.

Remarks. Although a considerable number of specimens were observed on one slab, the specimens are all so much distorted and especially flattened out that they present an entirely different aspect from the normal outline. We have figured also one of these flattened specimens (plate 5, figure 3) to facilitate recognition of the species. Even if the specimen selected as type is a little compressed laterally and therefore too ventricose and elongated, the general outline will not approach that of W. cincta and the characteristic concentric folds of the latter have not been observed in any of the cotypes.

Doctor Ulrich considers this species as being more closely related to W. subcarinata Ulrich (from the lowest Trenton of Minnesota), W. saffordi Ulrich (lower Stones River) and W. cancellata (Walcott). From W. subcarinata our species is distinguished by the oblique outline, the more convex posterior margin and longer anterior end; from W. cancellata by the surface sculpture. W. saffordi is a much older form.

Orthodesma ? subcarinatum nov.

Pl. 5, fig. 5-8

Description. Shells small, elongate, narrow and moderately arcuate, the length from two and one-half to three times the greatest posterior height and from three and one-fourth to three and one-half times the height at the beaks; valves rather strongly convex, culminating in about the middle of the umbonal ridge. Dorsal and ventral margins distinctly diverging posteriorly, the former straight or but very gently arcuate, the latter with a slight and broad sinus in the middle. Anterior end narrow, produced, the posterior end well rounded and quite convex above the somewhat more abruptly rounded basal part and passing gradually into the hinge line. Beaks not prominent, compressed, about one-fifth of the length of the shell from the anterior extremity; umbonal ridge subcarinate, a very marked feature above and traceable to the postero-basal margin. Mesial sulcus well defined and an obscure broad ridge passing from the beak obliquely forward and downward to the antebasal angle. Surface with irregular undulations and fine intercalated lines. Muscular scars not distinct.

Position and locality. Rather common in a bed of dark gray sandy shale of the Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. Doctor Ulrich writes me regarding this species that it belongs to an early group of Modiolopsidae, combining, with some of its own, the characters of Modiolopsis and Orthodesma, adding: "Its nearest ally is O. subnasutum. Another close ally is the Modiolopsis milleri (Cincinnati), a third M. arguta Ulrich (Black River). Several other species of the group which will some day be distinguished generically are figured on plate 36 of my Minnesota report. The Snake Hill species differs from all in its more sharply defined umbonal ridge. None of the specimens retains its original outline. One (plate 5, figure 5) comes nearest the normal." We have used the latter as type of the species and based our description upon this specimen. The specimen (plate 5, figure 7) is clearly too elongate by lateral compression; there occur specimens which possess not half that relative length and are compressed in antero-posterior direction. It also appears to us that O. subcarinatum possesses a more evenly rounded posterior margin than O. subnasutum and is relatively a little higher posteriorly, and is smaller; but otherwise it is hardly distinguishable from the western Galena form.

Prolobella ? trentonensis (Conrad)

Pl. 5, fig. 4

This species was first described as Avicula trentonensis by Conrad (Jour. Acad. Nat. Sci., 1842, 8:240) from the Trenton limestone and shortly after (title 3, page 161) by Hall as occurring in "the central and higher portions of the Trenton limestone at Middleville, and in the calcareous layers in the Utica slate at Coldspring, Montgomery county, N. Y." It has been found by us to be not uncommon in the Canajoharie beds at Canajoharie and the old locality of Coldspring is in the same formation not far away on the other (north) side of the Mohawk river.

In the Geology of Minnesota (title 38, page 532), Doctor Ulrich states of this species that it is almost certain that it belongs to his genus Prolobella which he places with the Modiolopsidae, and that it does not belong to the true Aviculidae, "their valves being equal and without the prolonged posterior wing."

Whitella elongata nov.

Pl. 5, fig. 9, 10

Description. Shell of medium size, compressed, subrhomboidal, a little wider posteriorly (by about one-fifth); length about three-fifths greater than posterior width, and shell about six times as long as thick. Anterior margin straight or even slightly concave in upper part, probably subangular at the anterior extremity of the hinge (the extremity not preserved); evenly rounded below, postbasal angle not well seen, apparently also strongly rounded, posterior margin very gently convex or gently straight (but partly seen) gradually merging into the dorsal line. Beaks small and little prominent and probably but little incurved, situated about one-fourth the length of the shell behind the anterior extremity; umbonal ridge very sharp at the beginning, possibly through oblique compression of the shell, becoming obsolete before reaching the postbasal margin. Surface gently convex posteriorly to the ridge and rather flat in front and below it. Surface marked by coarser, distant lines of growth and fine intercalated concentric lines. Escutcheon and hinge not seen, muscular scars but faintly.

Position and locality. Olive gray shaly sandstone of Snake Hill (Trenton) beds at Snake hill, Saratoga county, N. Y.

Doctor Ulrich writes me regarding this species that it belongs in the group of W. compressa Ulrich and W. ohioensis Ulrich, but is more elongate. The former species occurs in the Middle Third of the Trenton shales of Minnesota, the latter in the lower Richmond beds of Ohio. We have obtained but a single specimen of this species, which is obviously rare in our Trenton shales.

Clidophorus foerstei nov.

Pl. 5, fig. 15, 16

Hall (title 3, page 301) cites C. planulatus (Conrad) as occurring besides in the Lorraine beds of northwestern New York, also in the altered slates of Waterford, Saratoga county, N. Y., and figures a specimen from that locality (op. cit. plate 82, figure 9e). We have in our earlier work (Bulletin 42) followed that authority in identifying the Clidophorus from the shales of the Hudson valley with the Lorraine form. The better preserved material since obtained at Snake hill has shown however that there are at least two species of this genus present in the Snake Hill beds, one of rather ventricose form, here described as C. ventricosus, and another that comes near to C. planulatus. Hall's above-cited type from Waterford belongs to this second species. As his own figure shows this species is also more ventricose than the C. planulatus although approaching it closely in general outline. By a careful comparison of the Snake Hill specimens with types of C. planulatus from the Lorraine beds, we have ascertained the following differences: the shell of C. foerstei is less elongate, or relatively higher, in C. planulatus the length being two to two and one-half times greater than the height, and in C. foerstei somewhat less than two times greater; while in the former species the ventral slope is very flat, and the shell much compressed, as expressed in the name; that of C. foerstei is more convex, although not nearly so as in C. ventricosus; the clavicle is decidedly shorter in C. foerstei.

Horizon and locality. Snake Hill beds at Snake hill, Saratoga county, and other localities of that formation in Saratoga and Albany counties.

Clidophorus ventricosus nov.

Pl. 5, fig. 11–14

Description. Shell of medium size for the genus or above; transversely subrhomboidal in outline; subalate; with the height a little more than one-half the length of the shell, anterior end rounded and narrower than the posterior one which is obliquely truncate; the ventral margin is rather strongly convex and the dorsal margin straight posteriorly of the beak and declining obliquely forward in front of the beak. The posterior dorsal and posterior ventral extremities are both subangular, the former obtusely, the latter acutely so; the anterior extremity is abruptly rounded. Beak small, placed about midlength between the anterior and posterior extremities, umbo not very prominent, shell culminating a little above the center; umbonal ridge broad and traceable to the postventral extremity. Anterior, ventral and posterior slopes evenly rounded, cardinal slope slightly concave. "Clavicular"[1] impression closely in front of the beak, broad but not strong, nearly straight, extending obliquely forward and downward about one-third the distance to the antero-ventral margin. Near the post-dorsal angle are seen (see plate 5, figure 13) small oblique hinge denticles or ribs that are found among Ordovicic forms only in Clidophorus. Muscular impressions not observed. Surface with several coarse varices of growth and fine, very regular concentric lines which are barely visible with the naked eye.

Horizon and locality. Not uncommon in the dark gray to olive colored sandy shale of the Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. This species is readily distinguished from C. planulatus (Conrad) by the much greater convexity of the shells. Doctor Ulrich writes me regarding the same that it shows the beak nearer midlength than it is in any described species; that it is most like an undescribed type from the Southgate division of the Eden at Cincinnati, and that it may be the same as one in the basal part of the Martinsburg shale in Pennsylvania, the specimens of which however are not good enough to decide the matter. The general form is as in Whiteavesia but the characteristic Clidophorus clavicle and the small oblique hinge denticles are present.

Ctenodonta levata (Hall)

Pl. 6, fig. 1

We have cited under this name certain small Ctenodontas from the sandy shale of the Snake Hill beds at Snake hill and elsewhere. Of the specimen figured Doctor Ulrich writes us that he can not distinguish it from specimens from Sacketts Harbor and the writer has taken occasion to compare it with some of Hall's types in the American Museum of Natural History. C. levata is a middle Trenton species; it has been cited from our Utica shale and other higher formations but probably erroneously.

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[1] This impression is currently termed the *clavicular impression*, but it is obvious that it does not result from the prop or buttress, called *clavicle* in more recent forms, which serves to reinforce the attachment of the resilium or lower ligament. The "clavicle" of Clidophorus is a buttress or lamina which by its position is clearly intended to support the anterior adductor. Its relation to that muscle is well shown in our plate 5, figure 15. The more recent Cucullaea, to cite an analogous case, possesses a like radial buttress for the support of the posterior adductor.

Ctenodonta declivis nov.

Pl. 6, fig. 2, 3

Description. Shell small, acuminate, subovate, height by one-fifth greater than the length, basal margin well rounded, nearly semicircular as in C. obliqua, anterior dorsal margin slightly concave, posterior dorsal margin convex. Beak prominent, situated a little anterior of the center, curved backward; umbonal ridge broad and little prominent, surface sloping gradually forward and more abruptly backward, shell moderately convex, culminating anteriorly of the center. Surface with faint growth lines. Interior characters not observed.

Position and locality. Olive gray, sandy shale of Snake Hill beds, Snake hill.

Remarks. C. declivis is in size and form closely allied to C. obliqua (Hall), a species that is found in all groups of the Cincinnati period. It differs from that species in being higher and having the beak more anteriorly, but may in a revision of the Ctenodontae be found to be but an earlier mutation of that long ranged Western form.

Ctenodonta prosseri nov.

Pl. 6, fig. 4, 5

Description. Shell small, moderately convex, broadly obliquely subtriangular, well rounded in front and broadly rounded below, narrow behind, with fairly large, prominent, incurved beaks, directed posteriorly and situated a little anteriorly (about one-seventh of length) of the middle; umbones carinate behind, the ridge slightly concave in a side view. Hinge not seen.

Position and locality. Snake Hill beds at Snake hill and other places in Saratoga and Albany counties, N. Y.

Remarks. Doctor Ulrich has pointed out to us that this species is closely allied to his species C. scofieldi (title 39, page 593) from the Trenton and Galena shales of Minnesota. Our species would seem to differ from the western form mainly in the somewhat more elongate form, the less evenly rounded anterior and posterior margins and the more posterior position of the beak.

Ctenodonta radiata nov.

Pl. 6, fig. 6

Description. Shell thin, of medium size, subovate, three-fourths as high as long, anterior margin broadly rounded, posterior oblique and nearly straight or gently convex in the dorsal part and rather sharply rounded below; the ventral margin is but slightly curved. Beaks very little prominent, situated a little more than one-fourth of the entire length behind the anterior extremity. Shell compressed-convex, more convex in posterior half, culminating posteriorly of center in the broadly rounded umbonal ridge. Surface markings consisting of a few growth varices and fine concentric lines, which are crossed on the posterior portion by straight radiating lines. Hinge and muscle scars not observed.

Position and locality. Dark gray to olive, partly sandy shales of Snake Hill beds, Snake hill, Saratoga county, N. Y.

Remarks. This is one of the largest Ctenodontas of the Snake Hill beds; it is readily distinguished from the others by its size, the thinness of its shell and above all the radiating lines. These latter, as several other characteristic features, it has in common with C. calvini Ulrich, a western Richmond (Maquoketa) species. It differs from that younger species in being relatively shorter, narrower behind and higher in front.

Ctenodonta recta nov.

Pl. 6, fig. 7, 8

Description. Shell small, compressed, convex, subtriangular in outline, one-third longer than high; beak rather large but little prominent, incurved, turned slightly backward, situated about midway between the extremities; anterior margin well rounded, posterior more abruptly, and ventral one broadly. Anterior dorsal margin slightly convex, posterior one distinctly concave, impressed so as to form a small lunette. Surface of shell almost uniformly convex, highest subcentrally; with a few well-marked varices of growth and fine concentric lines. Hinge plate and muscular scars not observed.

Position and locality. In the dark sandy shale of the Snake Hill beds at Snake hill and elsewhere.

Remarks. This small type appears to us to be most similar to C. medialis Ulrich among the western Trenton forms, with which it has the general outline and the position of the beaks in common. Our species is, however, more elongate and possesses a more convex anterior margin.

Ctenodonta subcuneata nov.

Pl. 6, fig. 9, 10

Description. Shell below medium size, compressed, only about one-eighth longer than high, and about one-eighth as thick as long, acuminate subovate in outline; umbones fairly prominent and beaks incurved, directed distinctly forward and situated between one-third and one-fourth of the length behind the anterior extremity; posterior and anterior ends about equally wide, anterior dorsal margin oblique, slightly concave, posterior dorsal slope slightly convex, postero-basal part well rounded and basal margin broadly rounded. Umbonal ridge broad and distinct only in umbonal region. Surface marked by a few varices of growth and fine concentric lines. Posterior muscle scar faintly seen. Hingle plate not seen.

Position and localities. In dark gray sandy shale of Snake Hill beds, Snake hill, Saratoga county, N. Y.

Remarks. This species is easily distinguished from the associated congeners by its rather high relatively flat shell. According to a note from Doctor Ulrich it is allied to the western Richmond species C. fecunda (Hall). It is relatively higher and less extended posteriorly than the latter.

Allodesma subellipticum Ulrich

Pl. 6, fig. 11

The Canajoharie shale above the falls at Canajoharie has afforded several specimens of a small thin-shelled pelecypod that are much flattened and fail to show any structure. Doctor Ulrich has referred them doubtfully to his Allodesma subellipticum, a species from the Galena shales of Minnesota.

Lyrodesma schucherti nov.

Pl. 6, fig. 12

Description. Shell elongate-ovate, twice as long as high, greatest height a little anterior to middle; anterior part drawn out, posterior one obliquely truncate; shell rather flat, greatest thickness subcentral; cardinal margin nearly straight or slightly declining each way from beak; anterior margin abruptly rounded, basal margin broadly and evenly rounded, posterior basal angle subacute, posterior margin gently convex, passing obliquely upward and forward to the obtusely and obscurely angular posterior cardinal extremity. Beak apparently small, situated fairly midway between the cardinal extremities, umbo not very prominent; umbonal ridge sharply angular. Anterior slope rounded, with a flattening of the nasute anterior extremity; ventral slope evenly rounded; posterior slope concave along the umbonal ridge, abruptly turning into the flat nearly vertical posterior cardinal slope. Surface of anterior and ventral slopes almost smooth, only faint, widely separated growth-lines being visible; the posterior slope bears five sharp radiating ribs and the posterior cardinal slope one or two obscure flat ribs.

Horizon and locality. Very rare (only one specimen found) in dark gray sandy shale of Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. This species is similar in form and size to the shell from the Trenton of Carlisle, Pa., which Hall had referred to the Lorraine species Nuculites poststriata Emmons (title 3, page 151). Ulrich (title 38, page 610) has pointed out that the Trenton Nuculites (now Lyrodesma) poststriata and the Lorraine form are not identical, and has referred the Trenton species with some doubt to his Lyrodesma cannonense. Our species is clearly more elongate than any of these. Doctor Ulrich writes me regarding this species: "Though of the same section of genus, this is not the same species as either of the two Lorraine species that are current under the name L. poststriatum. My Black River L. acuminatum is also one of this section and even nearer. The broader and more common of the two Lorraine species to which the name poststriatum should be restricted, would seem to be a larger shell than this Snake Hill species. The latter is not only smaller but is relatively lower (from beak to ventral margin), relatively wider posteriorly and less strongly convex in the ventral part of its outline."

Hall (op. cit. page 302) cites also Lyrodesma pulchella, a species which typically occurs in the Lorraine beds at Pulaski, as occurring in the "black glazed slates near Waterford" and figures (plate 82, fig. 12c) a small specimen from that locality. Since we now know that the shales about Waterford are all of Trenton age, being partly Canajoharie and partly Snake Hill shales, it is an *a priori* inference that this small specimen is no longer referable to S. pulchella. A comparison of the figures of the Pulaski type (plate 82, figure 12a) and of the Waterford specimen (12c) shows marked difference in the position of the umbo and the general outline. The latter belongs apparently to one of the small Ctenodontas described from the Snake Hill beds; at any rate it is not identical with the L. schucherti here described.

Solenomya ? insperata nov.

Pl. 6, fig. 13, 14

Description. Shell rather small, very elongate, narrowing anteriorly, its length three times its height, greatest height one-sixth the length from the posterior margin; little convex; the greatest thickness not quite one-fourth the height. Umbones little prominent, situated very posteriorly, one-eighth the length of the shell from the posterior extremity; beaks apparently small and projecting slightly above the hinge. Cardinal and basal margins straight, converging gradually anteriorly; posterior margin slightly concave above and nearly vertical in the lower half; anterior margin evenly rounded. Umbonal ridge distinct and sharp, the anterior slope evenly rounded in the posterior part and becoming rather flat in front; the posterior slope steeply oblique, concave above (apparently with an elongate elliptic area) and flat below. Surface with irregularly spaced concentric folds which are most prominent on the anterior slope and the umbonal ridge and numerous fine concentric raised lines between and upon the folds.

The interior characters have not been seen, no casts of the interior having been obtained.

Position and locality. Rare (but four specimens collected) in the sandy mud shale of the Snake Hill beds at Snake hill, Saratoga county, N. Y.

Remarks. Doctor Ulrich writes me regarding this remarkable pelecypod that its relations seem to be with Solenomya or Clinopistha — both Devonic and Carbonic genera — rather than with any Ordovicic shells known to him, the short end seeming to be the posterior, and he suggests that the species belongs to Solenomya or a new genus. As far as the shale material permits of observation, the beaks are inclined toward the longer end of the shell, corroborating Doctor Ulrich's inference. Since our material does not give any clues to the interior characters and there are no important features apparent that would distinguish the form from Solenomya, we have, for the present, left the species with that genus. If this reference is correct, the species is the first representative of the Solenomyidae in the Ordovicic.

Cuneamya acutifrons Ulrich

Pl. 6, fig. 15, 16

In the olive and dark gray sandy shales of the Snake Hill a species occurs which has been identified by Doctor Ulrich with a form from the lower Trenton at Cincinnati, known to him since 1880 and in manuscript since 1886. Doctor Ulrich's description kindly sent to us at our request is as follows:

Description. Shell exceeding medium size for the genus, moderately convex, with the point of greatest convexity near the middle; outline transversely elongate, subovate or subrhomboidal, prowlike in front, highest in posterior half, narrowing anteriorly to the sharply produced antero-dorsal extremity; umbones large, prominent, the beaks strongly incurved and situated well forward; anterodorsal edge subparallel with, but appreciably lower than, the hinge line, inflected so as to form a narrow, almost linear, lunule; anterior margin trending backward from the sharp dorsal extremity in a gently sigmoid curve to the ventral side; ventral edge nearly straight, with a barely suggested sinuosity in front of the middle; posterior margin somewhat truncated, moderately oblique, sharply rounded where it joins the dorsal line and more broadly curved in the lower third; dorsal edge nearly straight, the part visible in a side view behind the umbones equaling in length about one-third, the whole to the apices of the beaks rather more than one-half, of the greatest length of the valves; escutcheon very narrow and shallow. Posterior umbonal ridge prominent, rounded, with the slope to the cardinal margin rapid and slightly concave. Two undefined furrows

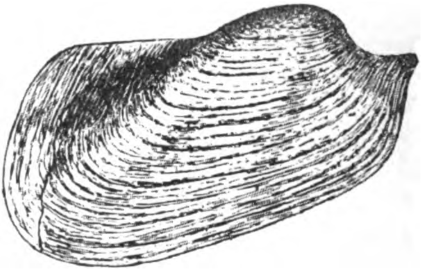

Fig. 30. Cuneamya acutifrons Ulrich.

Holotype. Natural size.

or sulci are present on the anterior third of the valve; one, very narrow, between the anterior umbonal ridge and the nasute anterior projection; the other running obliquely backwards from the anterior side of the umbones, to the basal margin, where it produces a slight sinuosity. Surface marked with irregular concentric wrinkles, which are generally most prominent over the more gibbous parts of the valve.

Length of best specimen seen, 2.4 inches; greatest height, measuring vertically across the anterior end of the posterior third, 1.15 inches; from a point back of umbones to basal margin, 1 inch; from highest point of umbones to antero-basal portion, 1 inch; length of nasute extension of anterior end, from its extremity to the anterior side of umbones, .38 inch; convexity of one valve, .5 inch.

This species differs from the typical forms of this genus in that the posterior half of the valves is much wider (higher) than the anterior. The generic reference is probably only temporary pending a revision of the shells of this family. Of described species only C. scapha Hall and Whitfield, bears any resemblance. The new species is readily distinguished by its greater width posteriorly, greater convexity, more prominent umbones, smaller lunule, much more acute and prolonged anterior end, less distinct mesial sulcus, and somewhat different surface markings. Closer allies are found among the undescribed species in the Ulrich collection at the United States National Museum.

Formation and locality. This species is rare, and hitherto has been found only in association with Whiteavesia cincinnatiensis (Hall and Whitfield) in a limestone bed exposed in the banks of the Ohio at Covington, Ky. This bed lies near the top of the Bromley shale, a formation corresponding very nearly to the Hermitage formation of middle Tennessee and central Kentucky. Correlating with New York formations its age would be early Trenton.

Holotype. U. S. Nat. Mus. Cat. no. 47314.

Doctor Ulrich observes that the Snake hill specimen is smaller and somewhat shorter, the latter perhaps due to pressure, but otherwise undistinguishable from the Cincinnati specimens.

Saffordia ulrichi nov.

Pl. 6, fig. 17, 18

For a great many years there has been in the State Museum a large fossil shell which had been sent in from one of the "bluestone" quarries at Schenectady[1] and which was considered as a problematicum. On being worked out it proved to be a large lamellibranch and this has been identified by Doctor Ulrich with his genus Saffordia. A second more fragmentary specimen obtained a year ago by the writer in a bluestone quarry between Schenectady and Aqueduct verifies the actual occurrence of the species in the Schenectady sandstone.

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[1] It is labeled: "Hudson River group, from Schenectada, near the College. From J. L. Coon."

Description. Shell large, transversely subovate, the height and length nearly as five is to seven. Dorsal margin nearly straight, very gently convex, anterior margin distinctly concave in upper part and moderately convex in the lower; the ventral and posterior margins form one very strongly and evenly rounded curve. Beaks subterminal, declining forward, strongly incurved, projecting forward nearly as far as the anterior extremity of shell; umbonal ridge very inconspicuous; angular along the dorsal edge. Probably a narrow sulcus on the dorsal slope; ventral and anterior slopes depressed convex. Escutcheon and lunule suggested but not clearly preserved in the type specimen. Surface marked with strong concentric folds that are most prominent in the upper half and become fainter on the umbonal ridge and along the anterior and ventral margins. Internal characters not observed.

Position and locality. In the sandstone of the Schenectady shale at Schenectady.

Remarks. This species differs by its dimensions from all other Saffordias, which are distinguished by their rather small size. In its general outline, the characters of the beak, etc. it most resembles S. ventralis Ulrich, a Richmond species of Minnesota and Wisconsin.

Archinacella orbiculata (Hall)

Pl. 7, fig. 1–6

Hall (title 3, page 306) has described as Carinaropsis orbiculatus a small patelloid gastropod from the "slates of the Hudson River group, near Waterford," which has been obtained by us in the Snake Hill beds of Snake hill and other localities, among them also the contorted shales near Waterford, N. Y. The original description of this species reads as follows:

> Suborbicular, apex subcentral, small, slightly inclined; surface finely striated. This species has the form of Orbicula, but the apex is remarkably elevated and no flat valve has been observed.

A comparison of the two type specimens kindly loaned to us by Dr E. O. Hovey, with the description and the original figures (op.

cit. plate 83, figures 8a, b, c) shows that owing to the preservation of the specimens the description and original figures are misleading, and the latter quite incorrect. We have for this reason refigured these types (plate 7, figures 3–6). The apex is broken off in both specimens and the scars of the beaks and the growth lines show that the apex was not subcentral as described, but situated well forward. One specimen (type 8a) is obviously flattened and the other much compressed laterally, as shown by the crest and hence too elongate and high. The surface is nearly smooth and exhibits only obscure finer and a few coarser growth lines. From the type specimens and others from Snake hill we have derived the following description of the species:

Description. Shell small, broadly subovate in outline, length not quite one-fifth greater than width, slightly wider in front than behind, obliquely subconical, apex situated about one-sixth of the length from the anterior margin, apex hardly incurved, apertural margin arched. In profile view moderately concave below the apex and gently convex behind. Surface markings consisting of fine growth lines and some deeper impressed lines near the margin. Length of type (plate 7, figure 3) 7.5 mm; width (too great) 6.2 mm; height 2.0 + mm.

Horizon and locality. Snake Hill shale at Snake hill and other localities in Saratoga and Albany counties.

Remarks. Hall (title 3, page 306) cites his species C. patelliformis, which is typically based on specimens from the Trenton limestone, also from the "semialtered shales near Waterford" without, however, figuring specimens from that locality, his "Hudson River" type (plate 83, figure 7) coming according to Whitfield and Hovey's Type-catalogue (page 50) from Pulaski and being hence a Lorraine type and quite obviously a species different from Archinacella patelliformis. The Waterford specimens differ from A. patelliformis of the Trenton limestone in the profile, the anterior line being much deeper cut in the latter species and the apex more protruding and also situated a little more forward; and in the presence of distinct concentric surface lines in that species. Our specimens of A. orbiculata from the Snake Hill beds are all somewhat laterally compressed, as shown by an irregular carina on the posterior slope, but they show quite clearly that this species was wider in front than in A. patelliformis and that probably it is allied to A. deleta Sardeson as figured by Ulrich and Scofield (1897, plate 61, figures 16–20).

Cyclonema montrealense Billings

Pl. 7, fig. 7

The gritty sandstone bed of the Snake Hill formation at Snake hill has afforded the impression of a small Cyclonema which has the characters of C. montrealense from the Trenton limestone of the island of Montreal. It agrees especially with that species in having the whorls "moderately ventricose, most prominent in the lower half," a rather deep suture, in the character of the spiral lines, of which there are about ten in 4 mm with one or two smaller ones between each pair of the larger lines. The spire is somewhat higher than Billings's description (title 4, page 30) and figure require, but since Ulrich (title 39, page 1059) after an exhaustive study of the western Cyclonemas states that the relative height of the spire is a very unreliable character, and that the form of the whorls is a better character, but that the surface markings have served him best of all in separating the various species, we do not feel warranted in attaching much importance to this difference in the spires.

Cyclonema cushingi nov.

Pl. 7, fig. 8–10

We had repeatedly observed fragments of a gigantic Cyclonema in the Snake Hill beds at Snake hill, but owe the fairly perfect specimen here figured to the collecting spirit of Prof. H. P. Cushing to whom we gladly dedicate this species in recognition of the fact that he does not disdain to be interested in fossils.

The specimens at hand are too badly crushed to allow a description of the species, but since the form is obviously closely allied to C. hageri Billings (1865, page 29), a Trenton form from Montreal island, it seems best to define this new species with the latter by determining its differences from the Canadian relative. The Snake Hill type has in common with the latter the large size and the number of whorls (about four). Also the form of the volutions appears to agree, the upper ones being rather flat or somewhat depressed in the middle, while it is not certain, whether the last volution was as ventricose as in C. hageri, or became concave in the type specimen through being crushed. We believe the latter on account of the presence of the oblique folds and a protruding lower rim in the specimen which indicate a former greater expansion of that volution. The apical angle is apparently less than in the other species, but the evidence in regard to this character is not conclusive. The surface sculpture exhibits revolving lines which are markedly closer arranged than those of C. hageri, where they are from one to two millimeters apart, while here the larger ones are one millimeter apart, but contain a smaller one between them. C. hageri possesses "strong angular ribs or undulations of growth from half a line (1 mm) to two lines (about 4 mm) apart becoming more prominent with age. The Snake Hill form has on the older volutions closely arranged subequal growth lines, which on the last volution become gathered into elevated bundles of lines, the middlemost of which are thicker and broader than the others. The high folds on the type specimen are largely due to the lateral compression of the shell.

It will be noticed that our species stands in its characters between C. montrealense and C. hageri. The form from the Jacksonburg limestone of New Jersey referred by Weller (title 53, page 186) to C. montrealense, has also its revolving lines farther apart than the Canadian type of that species and more convex volutions, and may represent a fourth expression of the same group. Its revolving lines are of the character of those of C. cushingi.

Hyolithes pinniformis nov.

Pl. 7, fig. 12, 13

Shell small, slightly bent in proximal portion, expanding somewhat rapidly, one side flattened or slightly convex, the other with a blunt median keel. The flat side is longer, projecting with an evenly rounded lobe beyond the aperture, while the keeled side forms a blunt reëntrant angle. The surface is furnished with closely arranged sharp arching transverse striae (growth lines, which are most distinct on the flat side; and with fainter longitudinal lines. Operculum not observed.

Horizon and locality. Canajoharie shale at Canajoharie, N. Y.

Remarks. This species belongs to the group of Hyolithes s. str. in distinction from the subgenus Orthotheca, Novak, according to the character of its aperture. It is distinguished from the other Trenton species of Hyolithes, save H. baconi Whitfield, by its more robust form. The latter species, from the Trenton of Wisconsin is considerably larger and the apertural lobe of the flat side is less projecting.

The type specimen (plate 7, figure 12) measures 13.5 mm in length and 4 mm in width. It shows a distinct, very concave septum in the apical portion. Our specimens are so flattened that their section can not be conclusively determined. It seems to have been elliptical with one side angular.

Orthoceras arcuolineatum nov.

Pl. 8, fig. 1, 2

Slender, small orthoceracone, increasing at the rate of .5 mm of diameter in length of 10 mm. Section elliptic, nearly circular, the minor and major diameters as 7.1 to 7.5 mm. Camerae shallow, nearly four times as wide as deep. Septa closely arranged, about 2 mm apart where the diameter of the conch is 7 mm deep, their depth approximately corresponding to that of the camerae. Sutures arching slightly up on one side. Living chamber not known. Siphuncle centren, small, about one-seventh the diameter of the conch; segments cylindrical, the funnels short and straight. Ornamentation consisting of relatively widely separated (about 2 in 1 mm) sharp raised transverse lines, or ridges, which are intersected by extremely fine longitudinal lines. The transverse lines are strongly bent upward on one of the narrow sides of the conch.

Horizon and locality. Canajoharie shale at Ford Edward, N. Y.

Remarks. This species is based on only the small fragment that is figured here. This shows, however, especially in the ornamentation, characters that distinguish it from other Trenton species known to us. It is apparently, from the character of the siphuncle, a true Orthoceras.

Orthoceras hudsonicum nov.

Pl. 8, fig. 3–10

Small to medium sized, slender, slightly curved cone, with closely arranged septa and subcentral, narrow siphuncle. The cone widens so gradually that in a distance of 50 mm it expands from 5 mm to 10 mm or less (measured in compressed specimen). The septa equal in depth the chambers; they are closely arranged, about 2 mm apart, where the conch is 7 mm wide; the sutures are straight transverse. The siphuncle is centren, wide, about one-third the width of the conch, the funnels apparently short and straight. The living chamber and aperture have not been observed. The nepionic conch possesses only fine longitudinal striae, of somewhat irregular character, and the mature conch transverse sharp striae, about four to the millimeter; the neanic conch exhibits an intersecting system of both, visible to the naked eye, while on the mature conch still shadowlike traces of the longitudinal lines are visible under the lens.

Formation and locality. In the Canajoharie shale at Alplaus creek, Saratoga county, N. Y., and other places.

Remarks. This species is easily recognized by three characters; its slender, slightly curved shell, the closely arranged septa and the delicate surface sculpture.

The specimens are all more or less crushed, and the septa mostly dissolved and the conch filled with shale. We have, therefore, been unable to satisfy ourselves completely as to the generic determination of the species, and we do not know whether it is a true Orthoceras or not. On account of the relative width of the siphuncle it approaches Baltoceras.

The surface sculpture corresponds exactly to that of Endoceras proteiforme var. tenuitextum, var. tenuistriatum and lineolatum Hall, as described in Palaeontology of New York, volume 1. These Trenton forms do not belong to Endoceras proteiforme but are orthoceratites that need revision. Also the common and often cited "Endoceras proteiforme" of the Utica slate (title 3, plate 85, figure 1) belongs in the same group which eventually will be referred to, we believe, as Orthoceras tenuitextum Hall. They all have the same rate of growth, the same closely set septa and the same characteristic surface sculpture. We would also have referred the species here described to Hall's species if it were not for the curvature of the conch.

A species identical with our type save its coarse cancellated sculpture, has been described by Walcott (title 9, page 22) as O. oneidense from the Utica shale of Trenton, N. Y.

The most interesting feature of the material from the Alplaus creek is the presence of the embryo shells or protoconchs on the partly pyritized and partly calcified nepionic portions of the conchs (see plate 8, figures 4, 5).

The history of the investigation of the protoconch of the orthoceratites is a very interesting one. Branca considered as the embryonal shell or protoconch the cup-shaped termination of the conch as usually found. Hyatt viewed this chamber as the first chamber and the cicatrix which it generally bears upon its distal surface as the remnant of the protoconch. The latter was figured by him in the *Genesis of the Arietidae* as a very small, shrunken wartlike appendix, the aspect of which was explained by assuming it to have been composed of conchiolin, which also accounts for its almost invariable absence. In 1893 Clarke (title 20, page 112) announced the discovery of a small fragment of an Orthoceras conch from the Devonic of New York that retains a good-sized calcified protoconch. This minute and interesting specimen was found in the same geological horizon (Styliola-limestone) with protoconchs of Bactrites and distinguished from them by the central position of the siphuncle. The very similar protoconchs and early stages of Bactrites were first described by Clarke in a subsequent paper (title 23, page 37) and more fully in the first part of the Memoir on the Naples Fauna (page 122). Hyatt in his *Phylogeny of an Acquired Characteristic* assumes regarding the protoconch of that Orthoceras the stand that this " form certainly has the characters of an Orthoceras, but the protoconch is large and like that of the Ammonoidea. The shell may be transitional from Orthoceras to Bactrites, but it is probably not a typical form of Orthoceras." This view which gives the small fragment from the Styliola limestone still greater phylogenetic interest, was later (op. cit., page 130) concurred in by Clarke, who considers it " conceivable that such differences as are here indicated by the young [of Orthoceras and Bactrites] may be totally extinguished in the later growth stages so that the mature form of the species in question may be before us, though present knowledge does not enable us to recognize it." Even if the unique small shell described by Clarke represents but a transitional form, it demonstrates that there must exist true Orthoceras with like large calcareous initial chambers. Indeed such were found not long after by Pocta.

In 1902 Pocta (title 50) published a note on the initial chamber of Orthoceras, his observations being based on the sections of diabas tuffa of the band e_1, of the Bohemian Upper Siluric. These sections showed clearly the presence of a baglike protoconch in both longiconic and breviconic orthoceratites, the species of which, however, could not be determined. Pocta obtained the following conclusions:

1 The genus Orthoceras possessed a calcareous initial chamber.

2 The form of the same was baglike, somewhat contracted downward, but always of greater width than the first air chamber.

3 This protoconch exists only in juvenile stages, later it is absent, and its traces in mature individuals are extremely rare (Clarke).

4 The first siphonal funnel was collarlike reflexed and thus formed the scar (Barrande's "cicatrix"). This first siphonal funnel has as a rule a different shape from that of the other funnels of the conch.

Our material consisted only of about half a dozen protoconchs which, however, were large enough (1.6 mm wide) to be broken out and in two instances made into thin sections. Both the exterior view and the sections verify Pocta's observations as to the width of the protoconch being greater than the first camera and the reflexed character of the first funnel. It will be noticed that in O. hudsonicum the volume of the protoconch corresponds approximately to that of the first camera.

This is the first observation of the protoconch of an Orthoceras in the Lower Siluric, Doctor Clarke's specimen coming from the Devonic and Professor Pocta's from the Upper Siluric. The different character of the nepionic conch of Endoceras has already been described by Holm in 1885 (Pal. Abh. von Dames and Kayser, volume 3, and Geol. Fören. i Stockholm Förhandl. 1896, volume 18). The protoconchs of orthoceratites are by no means rare in the Utica shale, for we had already obtained a large series of pyritized specimens at Dolgeville some fifteen years ago. These, however, were lost in transportation and the bed has become inaccessible by the building of a dam. The Dolgeville material was the same or a very closely related species.

Oncoceras (?) sp.

Pl. 8, fig. 12

A completely flattened specimen from the Canajoharie shale at North Albany. Its condition does not allow either a definite generic determination or a sufficient specific diagnosis. The living chamber was short and the apertural portion somewhat contracted; the aperture apparently regular and circular. The septa are seen only faintly, they were closely arranged and arched on both the ventral and dorsal sides. The siphuncle is very indistinct, apparently with straight segments. The form seems to be distinct from the other Trenton species of Oncoceras but would not warrant being named.

Conularia trentonensis var. multicosta nov.

Both the Schenectady and the Snake Hill beds have furnished specimens of a Conularia which possesses the characteristic apical angle (18°–20°) and sculpture of C. trentonensis, i. e. a system of transverse ridges crossed by closely set longitudinal bars, with the difference, however, that the sculpture is much finer in the shale variety, the ridges and bars being just about twice as closely set and correspondingly lower than in the trentonensis (15 to 17 ridges in 5 mm as against 6 to 9 in C. trentonensis). This difference having been found to be constant in all specimens observed in the shale (Snake Hill beds at Watervliet and the Schenectady beds at Schenectady and Schoharie Junction), it becomes necessary to recognize it as of at least varietal importance. We therefore propose to distinguish this form as var. multicosta.

It represents the other extreme of variation to the type described by Emmons (Amer. Geology, 1:208) as C. hudsonia from the Lorraine beds at Lorraine, N. Y., which latter form exhibits the trentonensis-sculpture about twice as coarse as the Trenton type.

A fragment of a specimen from Watervliet retains part of the apertural lobe. The sculpture on this consists of the transverse ridges which are much more crowded than on the lateral faces of the shell and sharply bent forward in the middle.

Eoharpes ottawensis (Billings)

Pl. 9, fig. 1

A single specimen found in a loose slab of Snake Hill shale on Snake hill, represents thus far this Canadian species in our State. The species was first described from the Trenton limestone of Ottawa (Can. Pal. Fossils, 1865, 1:182); later a doublure of a head shield from the Galena of Wykoff, Minnesota, was also referred with doubt to this species by Doctor Clarke (title 32, page 757). Weller (title 53, page 191) has also recognized the species in the fauna from the Jacksonburg limestone at Jacksonburg, N. J., and Bassler (title 62, page 111) lists it from the Liberty Hall limestone (Chazy) of Virginia.

Our specimen has been slightly laterally compressed and therefore appears somewhat more slender than the type, but otherwise it fully agrees with the original drawing of the latter. It also distinctly exhibits the surface punctae characteristic of Billings's species.

Isotelus gigas DeKay

Pl. 10, fig. 1

We figure here a fairly well-preserved specimen of this widely known trilobite which, labeled as coming from the bluestone quarries at Rexford Flats, N. Y., has been in the State Museum for some time. It is the only example of this species known to us from the Schenectady beds and appears to agree in all essential characters with the Trenton type. The fact that it is narrower and higher is due to lateral compression.

Proëtus undulostriatus (Hall)

Pl. 9, fig. 2, 3

Olenus undulostriatus Hall. Pal. N. Y., 1847, 1:258, pl. 67, fig. 3a, b.

Cf. Proëtus parviusculus Hall. 13th An. Rept. N. Y. State Mus. Nat. Hist., 1860, p. 120.

Elliptocephala undulostriata S. A. Miller. North Amer. Geol. & Pal., 1889, p. 546.

Bathyurus sp. Whitfield & Hovey. Bul. Amer. Mus. Nat. Hist., pt. 1, 1898, 11:70, 71.

Proëtus parviusculus Ruedemann. N. Y. State Mus. Bul. 42, 1901, p. 536.

Cyphaspis hudsonica Ruedemann. N. Y. State Mus. Bul. 49, 1901, p. 64, pl. 4, figs. 8, 9.

The writer described in 1901 several small cranidia from the black limestone pebbles from the Rysedorph Hill conglomerate which are especially characterized by a fine system of transverse or concentric sculpture lines, as Cyphaspis matutina, and another cranidium of broader habit from the supposed Upper Utica shale of Green island as C. hudsonica. Collecting in the Snake Hill beds at Snake hill furnished a few years ago a cranidium (plate 9, figure 3) which not only exhibits the identical characteristic sculpture of C. matutina but also resembles it in all other features with the exception that it is a little broader and the frontal limb distinctly narrower. In the latter features it fully agrees with the C. hudsonica which comes from beds which we now know to be identical with the Snake Hill beds. This latter specimen proves on reinvestigation to be exfoliated, for which reason the surface sculpture is not observable while the glabellar furrows are more distinct.

Hall had in 1847 described and figured as Olenus undulostriatus from the "Hudson River group" of Snake hill, the mold of a carapace and part of the thorax of a trilobite which since that author had referred in his early work a considerable number of Lower Cambric fossils to the "Hudson River group," had also been placed by catalogers in the Cambric, or rather since the original description is very brief and the figure quite unsatisfactory, it has been left out of consideration in discussions of the Lower Siluric faunas. Hall's type, which was kindly loaned to us by Dr E. O. Hovey, proved, from gutta-percha squeezes, to be specifically identical with the specimens in our collection from Snake hill and also with the other specimen formerly described by us as Cyphaspis hudsonica. We have here (plate 9, figure 2) introduced a new figure of the original of Olenus undulostriatus from a gutta-percha squeeze.

While Hall referred his species to Olenus and Miller placed the same under Elliptocephala, Whitfield and Hovey in the catalog of palaeontologic types of the American Museum of Natural History, have cited that type as Bathyurus sp.

We had placed the cranidia from the Rysedorph Hill conglomerate and of Green island with Cyphaspis on account of the form of the glabella and the large basal lobe. From inspection of the whole carapace and the thorax we have however become convinced that those species should be more properly referred to Proëtus, the isolation of the basal lobe being too indistinct for Cyphaspis and the carapace relatively too broad and the glabella not prominent enough. On the other hand, while we recognize the similarity of the carapace of P. undulostriatus to that of Bathyurus in its former generalized conception. we doubt that this genus, as characterized by its genotype, B. extans (Hall), could be made to receive forms like the present with a distinct thick anterior margin and a much broadened base of the glabella through a more or less prominent basal lobe. All these are features characteristic of Proëtus and are becoming still more emphasized in Cyphaspis, but absent in Bathyurus.

Proëtus matutinus Ruedemann from the Rysedorph Hill conglomerate is obviously a closely related older form. the black pebbles being probably of Black River and the Snake Hill beds of Trenton age. It is mainly distinguished by the broader frontal limb of the cranidium. The glabella is also distinctly more convex. but this may be due to the preservation in limestone, the shale fossils always being more or less flattened. The fine anastomosing sculpture lines are identical in P. undulostriatus and matutinus.

In New York State Museum Bulletin 42, 1901. page 536, the present writer has cited from the " Middle Trenton shales," exposed at the Brothers quarry at South Troy. Proëtus parviusculus Hall, from a cranidium collected by him at that locality.

The same is now packed away and at present not accessible, but the writer feels sure that this cranidium also belongs to P. undulostriatus from his recollection of the minute fossil and from the fact that P. parviusculus is clearly a very close relative of P. undulostriatus. The small specimen from Troy was exfoliated and therefore failed to show the striae.

P. parviusculus in size and outline of carapace and glabella would appear to be difficult of differentiation from the Snake Hill species. The fact that its surface is described as " smooth, or very finely granulose " would seem to furnish a distinctive character.

Beecher (1895, p. 174) states, however, regarding the surface sculpture of this species: " In the original description of this species, no mention was made of fine undulating striae ornamenting the entire dorsal surface of the test, nor of the basal lobes of the glabella. Both these features are present in the type specimen, which is from Cincinnati, Ohio, as well as in all the specimens from the Utica slate near Rome, New York."

If it were not for the fact that the cheeks and glabella of the types of P. undulostriatus and P. hudsonicus are relatively broader than those figured of P. parviusculus and the genal spines diverging instead of being subparallel, we should not hesitate to consider parviusculus a synonym of the older term. Since these differential characters in the scant material at our disposal — and especially in the type specimen — may be due to longitudinal compression, it is possible that later collections will demonstrate the identity of the Cincinnati and Snake Hill forms. At any rate, if different, they are very closely related.

The species here described presents in its outline great similarity to Proëtus latimarginatus Weller from the Jacksonburg limestone of New Jersey. The latter type is however described as possessing a finely granulose surface.

Acidaspis crossota (Locke)

Pl. 9, figs. 4, 5

A small Acidaspis from the Indian Ladder beds, represented by a cranidium and several fine cheeks, has been identified by Doctor Ulrich with Acidaspis crossota Locke, a form hitherto known only from the Cincinnati group of the neighborhood of Cincinnati. It is recorded by Nickles as ranging through the Eden (" Utica ") shale of Cincinnati.

Calymmene senaria Conrad

Pl. 9, fig. 6–10

The Canajoharie shale in the Mohawk valley often contains as one of its more frequent fossils quite large specimens of Calymmene senaria. These, as first noticed by Doctor Ulrich, bear upon the occipital ring a larger median tubercle not found in the common Trenton or Utica specimens and obviously representing a varietal character. It is distinctly seen on the specimen reproduced in figure 6, but the largest specimen here figured also possessed a larger, though flatter elevation upon the middle of the occipital ring.

The material of this species from the Canajoharie shale proved especially interesting through the fact that the fine black shale has retained the earlier growth stages. Among the latter was found a well-preserved specimen of a protaspis (see plate 9, figure 7), which to our knowledge has not as yet been observed of this genus. The very prominent marginal eyes and the fine segments of the glabella, the middlemost of which is largest, are the most striking features of this trilobite embryo. We also figure a nepionic and early neanic stage to illustrate the changes in the glabella, leading to the suppression of the embryonic annulations. The protaspis here figured is practically identical with that referred to Proëtus parviusculus by Beecher,[1] and the question arises whether it should not also be referred to that genus. Since our protaspis is fairly well connected with the adult Calymmene by the neanic stages here figured, and Proëtus parviusculus has not been found associated with it in the Canajoharie beds; we feel certain of its ontogenetic connection with the common Calymmene senaria of that formation.

Ulrichia ? bivertex Ulrich

Pl. 9, fig. 11, 12

Associated with Primitiella unicornis the Canajoharie shale at Canajoharie contains in considerable numbers an ostracod of rather striking appearance through two prominent tubercles near the dorsal margin. This species was first published by Doctor Ulrich as Leperditia bivertex (title 8, page 10) from the neighborhood of Cincinnati and is now referred by him to the genus Ulrichia with some doubt. It is usually as at Canajoharie associated with Primitiella unicornis in the lower Trenton and in the " Utica " of Cincinnati.

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[1] The larval stages of Trilobites. Amer. Geologist 16, pl. 9, figs. 5, 6.

Eurychilina subradiata Ulrich

Pl. 9, fig. 16

A specimen of this species which has been recorded by Doctor Ulrich (Jour. Cin. Soc. Nat. Hist., 1890, 13:126; Geology of Minnesota, part 2, 1897, 3:661) from " Birdseye and Lower Trenton " of the Middle West (Minnesota-Tennessee) was also collected in the shaly basal Trenton of the Canajoharie section. The New York type is according to Doctor Ulrich a close derivative of the western form which is there a good Black River species.

Primitiella unicornis Ulrich var.

Pl. 9, fig. 13, 14

This minute ostracod was first made known by Doctor Ulrich in 1879 (title 8, page 10, plate 7, figure 4), and later more fully described and illustrated in the Geology of Minnesota (title 38, page 649). It is stated by its author to occur abundantly in the lower part of the Cincinnati group about Cincinnati and also recorded by the same authority from near the base of the " Hudson River group " in Minnesota and in a slightly different variety from Manitoba (title 15, page 50). Professor Nickles (title 49, page 71) records it from his lowest division of the " Utica " at Cincinnati. Doctor Ulrich has denoted the Canajoharie form as corresponding to the " basal Trenton variety." This variety appears to us to be distinct from the type of the species in being more elongate and thicker in the posterior part. The spine is somewhat larger and the slight node in the dorsal depression larger.

It has been observed by us in this State only in the lower part of the Canajoharie shale.

Ceratopsis chambersi (Miller) var.

Pl. 9, fig. 15

The Indian Ladder beds at the Indian Ladder have furnished us an ostracod which like many of its associated forms has before been only known from the Cincinnati region, whence it was first described by S. A. Miller (Cincinnati Quar. Jour. Sci., 1874, 1:234) and from the West. It has been more fully made known by Doctor Ulrich (Jour. Cinc. Soc. Nat. Hist., 1890, 13:112; Geology of Minnesota, part 2, 1897, 3:676).

This species which in several varieties occurs in the Trenton, Cincinnati and Richmond formations, is characterized by the spine-like form of the postdorsal process. Our specimen represents a variety that may be peculiar of the Indian Ladder beds. One of its features is the separate development of the upper end of the post-medium ridge as a small rounded node. Doctor Ulrich (op. cit. page 676) figures a similar specimen and remarks that it is the only case of the kind seen and may be abnormal.

Pollicipes siluricus Ruedemann

In New York State Museum Bulletin 42 (1901, page 518) the writer described as Pollicipes siluricus a crustacean from the Snake Hill beds of Green island, N. Y., announcing it as the first lepadid or "goose barnacle" yet known from the Paleozoic. He has since learned that Dr W. S. Aurivillius had before (Bihang Svenska Vet.-Akad. Handl., 28, Afd. 4, No. 3, 1892) made known two species of Pollicipes and seven of Scalpellum from the Upper Siluric of Sweden, thus leaving to the Snake Hill barnacles only the distinction of being the first Lower Siluric or Ordovicic ones known.

In a note on the geologic distribution of Pollicipes and Scalpellum by Doctor Bather (title 46, page 112) this author suggests that my figures of Pollicipes siluricus belong to more than one species and that therefore a holotype of P. siluricus should be selected and the species separated. Although Aurivillius's species are based on differences in form of plates etc. of no greater amount than those in our material, we do not deem it safe at present to distinguish more than one species for the reason that the plates have suffered distortion in the much contorted shales, and we therefore restrict ourselves here to designating the original of figure 17, plate 2, *op. cit.* as the holotype.

Technophorus cancellatus Ruedemann

Pl. 9, fig. 17, 18

This peculiar fossil has been described by the writer (title 47, page 572) from the shale of Green island, Albany county, N. Y., then referred to the Utica, where it occurs in the same association as found on Snake hill. We figure here two specimens showing additional features. Our species is a very close ally of T. punctostriatus Ulrich (title 22, page 685) from the Cincinnati group, with which it has above all the striking surface ornamentation in common. Doctor Ulrich writes me that T. cancellatus has a proportionally greater length and more prominent rostrum. Since T. punctostriatus occurs in the middle beds of the Cincinnati group it is also considerably younger than the Snake Hill species.

Miller considered his genus Technophorus as belonging to the lamellibranchs and Ulrich (title 38, page 612) retained the genus in that class, pointing out, however, that in the surface ornamentation and the character of the beaks as they appear in casts of the interior, the genus differs from all known Paleozoic representatives of the class, with the possible exception of Ischyrina Billings.

The markings are such as to suggest the crustacean nature of Technophorus and the beaks form a single pyramidal prominence instead of two separate points as in lamellibranchs. The Snake Hill species seems to be distinguished from the others by an especially prominent beak (plate 9, figure 18).

Doctor Clarke in describing a very similar fossil from the Oneonta sandstone (New York State Museum Memoir 6, part 2, 1904, page 406) has stated that he is "more inclined to regard these clavicle-bearing genera (Technophorus and Ischyrina) as bodies like Ribeiria and Ribeirella which Schubert and Waagen have shown to be apodiform crustaceans (Jahrb. der k. k. geol. Reichsanst. 1903, 53:337), adding that "it is doubtless true that Technophorus is a ribeirioid crustacean." Doctor Ulrich now also considers these genera as crustaceans.

EXPLANATION OF PLATES

Plate 1

Spnenophycus latifolius (Hall)

Page 73

Fig. 1 Example resembling Hall's type.
Fig. 2 Lobate thallus, showing short conical marginal cavities.
Fig. 3 A large fragment of thallus, showing at the right lower margin the cavities, giving it a lobate appearance.
Fig. 4 A thallus showing very distinctly the conical marginal cavities.
Fig. 5 Large thallus with radiating impressions and cavities.
Fig. 6 Small thallus showing perfect margin with cavities.
Fig. 7 Thallus with complete outline.
Fig. 8 Thallus with broad, partly overlapping lobes.
Fig. 9 Thallus showing parallel, distally diverging lines and a medial row of double pits, doubtfully referred here.
Fig. 10 Thallus with extremely lobate outline. The specimens, figures 4–6, 8–10, only doubtfully referable to this species.

Horizon and locality. Schenectady beds. Aqueduct near Schenectady, N. Y.
All figures are natural size. The originals are in the State Museum.

LOWER SILURIC FOSSILS.

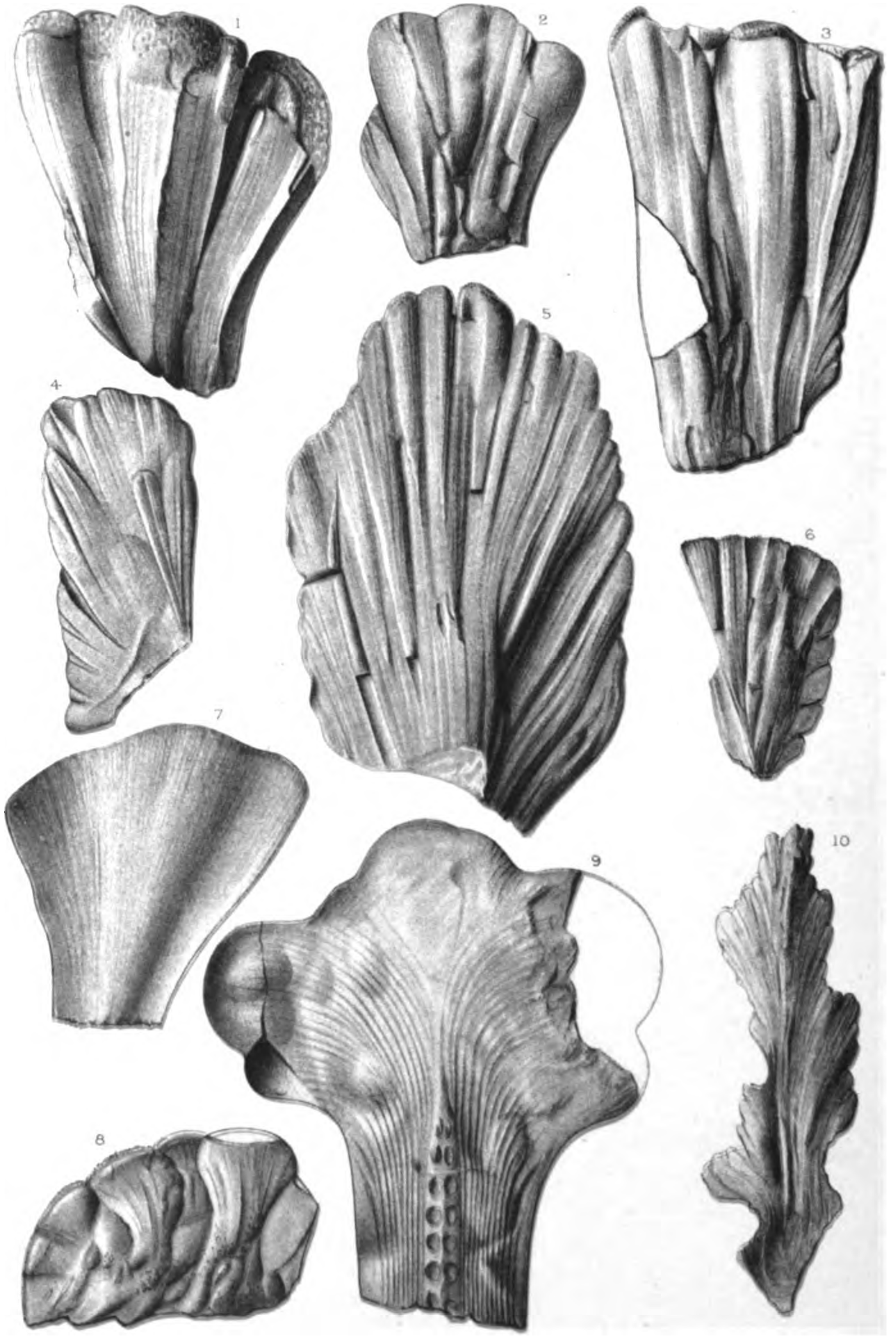

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Plate 2

Sphenophycus latifolius (Hall)

Page 73

Fig. 1-4 Specimens showing the more common aspects of the fossil Natural size. Figure 1 shows also a bandlike breaking up of the test; figure 2, the most frequent and typical aspect of the bodies; figure 3, showing a breaking of the stem into longitudinal shreds at *b;* figure 4, specimen with long, thin pedicel.

Fig. 5 Specimen in which the upper test has become exfoliated, revealing a flattened interior space.

Fig. 6 Specimen in which the wrinkling suggests the originally inflated condition of the bulb; it also shows a bandlike shred of the pedicel.

Fig. 7, 8 Specimens remarkable for the extreme inflation of the bulb. Figure 8 shows at *b* a cylindrical section of the pedicel.

Fig. 9 Specimen showing a marginal, distal wrinkle and slight extension resulting from the flattened apex of the bulb, folded upon itself.

Fig. 10 Specimen also distinctly showing the apical wrinkle or fold, and a slight inflation in the pedicel.

Fig. 11 Finely preserved specimen showing the flattened oval space at the top of the bulb and a bulbous swelling of the pedicel (at *a*).

Fig. 12 Specimen showing finely the apical flattening of the bulb with a central, probably accidental perforation.

Fig. 13 Fragment of fronds of Sphenophycus latifolius, showing their spiral arrangement and the stems of several specimens of bulbs.

Fig. 14 Circular, originally probably spherical body found associated with the bulbs.

Figure 9-12 are x 2; the others natural size.

Horizon and locality. Schenectady beds. Aqueduct near Schenectady, N. Y.

Dictyonema arbuscula (Ulrich)

Page 77

Fig. 15 Specimen in natural size.

Horizon and locality. Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Dictyonema multiramosum nov.

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Fig. 16 Holotype. Natural size.

Horizon and locality. Schenectady beds. Rotterdam Junction, Schenectady county, N. Y.

Diplograptus peosta Hall

Fig. 17 Specimen in natural size from Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Diplograptus (Mesograptus) mohawkensis nov.

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Fig. 18 Typical (holotype) specimen from Canajoharie shale, Swartztown creek near Amsterdam, N. Y. Natural size.

Fig. 19 Specimen (paratype) from Canajoharie shale at the Carlsbad Spring near Saratoga Springs, N. Y.

Diplograptus (Amplexograptus) macer nov.

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Fig 20, 21 Cotypes. Natural size. Uppermost Canajoharie shale at Minaville, Montgomery county, N. Y.

The originals are in the New York State Museum.

LOWER SILURIC FOSSILS.

N. Y. State Museum. Bull. 162 **PLATE 2**

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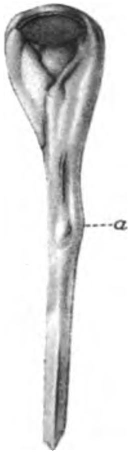

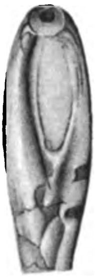

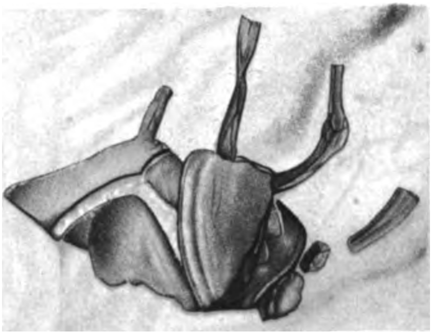

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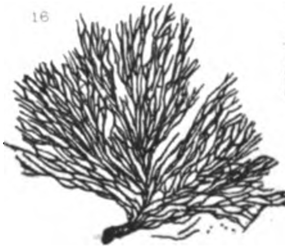

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Plate 3

Taeniaster schohariae nov.

Page 88

Fig. 1 Holotype. x 5. The middle arm exhibits the ventral view.
Upper Schenectady beds near Schoharie Junction, Schoharie county, N. Y.

Edrioaster saratogensis nov.

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Fig. 2 Holotype. x 5. Specimen showing the five ambulacral rays, oval aperture, subambulacral plates (at *a*) and the inner thecal plates of the interambulacra.

Fig. 3 Paratype. x 5. Specimen showing three of the oral plates, distinctly the suture-lines of one interambulacrum and what is apparently an anal pyramid (at *a*).

Fig. 4 Paratype. x 5. A badly crushed specimen which however well exhibits the extremital part of an ambulacral ray at *b;* and the subambulacral pavement of plates at *a*.
Snake Hill beds at Snake hill, Saratoga county, N. Y.

Heterocrinus ? gracilis Hall

Page 86

Fig. 5 A specimen from the original locality of the species. Natural size.
Snake Hill beds at Snake hill, Saratoga county, N. Y.

Carabocrinus cf. **radiatus** Billings

Page 86

Fig. 6 A calyx plate. Natural size.
Snake Hill beds at Snake hill, Saratoga county, N. Y.

All figures are taken from squeezes. The originals are in the New York State Museum.

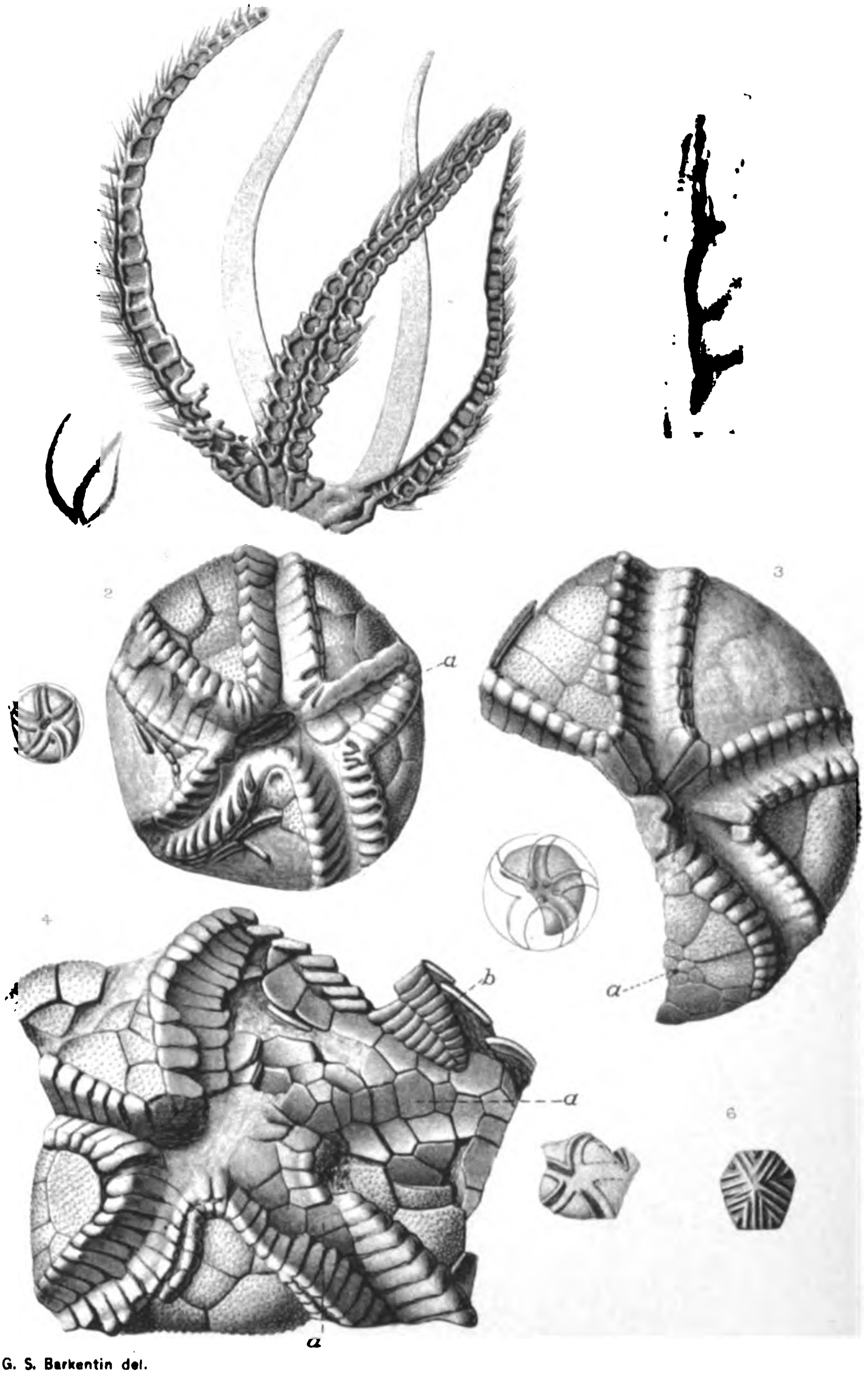

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Plate 4

4

Lingula rectilateralis Emmons

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Fig. 1 Specimen figured in natural size.
Schenectady beds. Dettbarn quarry, Schenectady, N. Y.

Orbiculoidea tenuistriata Ulrich

Page 91

Fig. 2 Pedicle valve. x 4.
Top of Frankfort shale, Frankfort gulf, N. Y.

Plectambonites sericeus (typus) Sowerby

Page 91

Fig. 3, 4 Two pedicle valves, showing the mesial fold. Figure 7 x 2; Figure 8 x 3.
Fig. 5 Brachial valve. x 2. From squeeze.
Fig. 6 Interior of brachial valve. x 2. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Plectambonites centricarinatus nov.

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Fig. 7 Holotype. Pedicle valve. x 4.
Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Plectorthis sp. cf. **whitfieldi** (N. H. Winchell)

Page 92

Fig. 8 Brachial valve. Natural size. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Plaesiomys retrorsa (Salter)

Page 93

Fig. 9 Brachial valve. Natural size. From squeeze.
Fig. 10 Cardinal portion of brachial valve. x 2. From squeeze.
Fig. 11 Pedicle valve. Natural size.
Fig. 12 Enlargement (x 5) of surface.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Plaesiomys cf. **porcata** McCoy

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Fig. 13 Pedicle valve. Natural size. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Clitambonites americanus (Whitfield)

Page 94

Fig. 14, 15 Two views of brachial valves. Natural size.
Fig. 16–19 Views of the pedicle valve. Natural size.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

All originals are in the New York State Museum.

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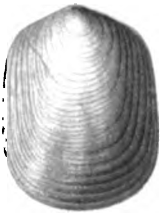

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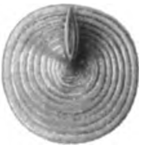

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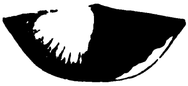

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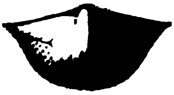

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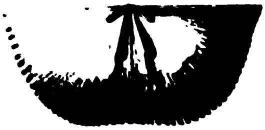

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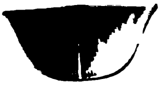

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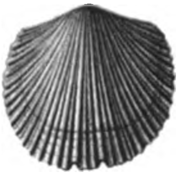

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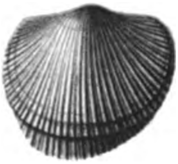

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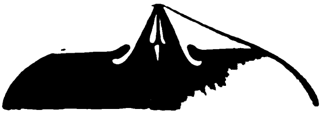

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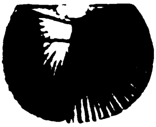

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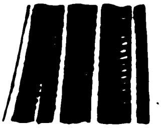

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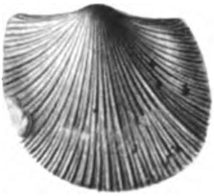

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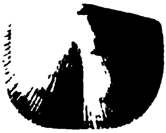

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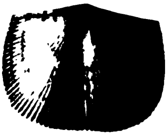

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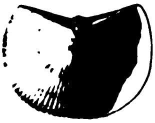

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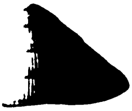

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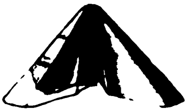

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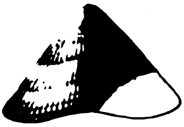

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Plate 5

Whiteavesia cincta nov.

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Fig. 1 Holotype. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Whiteavesia cumingsi nov.

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Fig. 2 Specimen that is probably but little distorted. Holotype. x 2.
Fig. 3 Another specimen, showing a frequent expression of the form. Paratype. x 2.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Prolobella ? trentonensis (Conrad)

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Fig. 4 Specimen. x 2.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Orthodesma ? subcarinatum nov.

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Fig. 5, 6, 7 Specimens (cotypes) showing the more frequent and apparently least distorted appearances of the species in the folded shales of Snake hill. x 1.5.
Fig. 8 Dorsal view. x 1.5.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Whitella elongata nov.

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Fig. 9 Holotype. Natural size.
Fig. 10 Dorsal view of same.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Clidophorus ventricosus nov.

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Fig. 11, 12 Lateral and anterior views of the holotype. x 3.
Fig. 13 A more elongate specimen showing hinge-denticles. x 1.5.
Fig. 14 A specimen with very distinct clavicle. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Clidophorus foerstei nov.

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Fig. 15, 16 Lateral and vental views of the holotype. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

All originals are in the New York State Museum.

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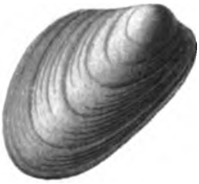

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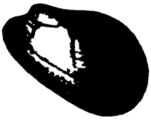

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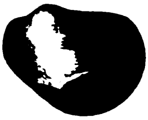

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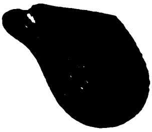

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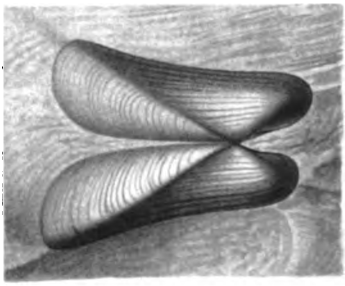

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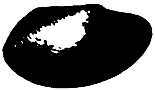

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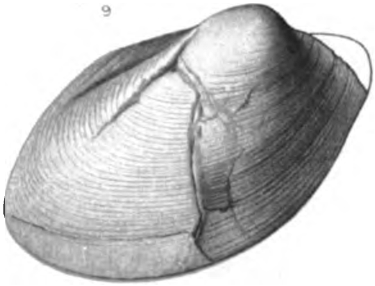

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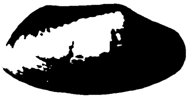

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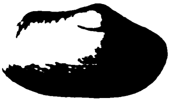

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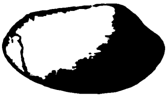

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Plate 6

Ctenodonta levata (Hall)
Page 100

Fig. 1 Right valve. x 2.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta declivis nov.
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Fig. 2, 3 Lateral and posterior view of holotype. x 2.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta prosseri nov.
Page 101

Fig. 4, 5 Lateral and posterior views. x 4.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta radiata nov.
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Fig. 6 Lateral view of holotype. Natural size.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta recta nov.
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Fig. 7, 8 Lateral and posterior views of holotype. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Ctenodonta subcuneata nov.
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Fig. 9, 10 Lateral and posterior views of holotype. x 1.5.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Allodesma cf. **subellipticum** Ulrich
Page 103

Fig. 11 Specimen. x 2.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Lyrodesma schucherti nov.
Page 103

Fig. 12 Holotype. x 2.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Solenomya ? insperata nov.
Page 105

Fig. 13, 14 Two specimens (cotypes) showing the common expression of the form. x 1.5.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Cuneamya acutifrons Ulrich
Page 106

Fig. 15 Anterior portion of specimen. Natural size.
Fig. 16 Surface sculpture. x 8.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Saffordia ulrichi nov.
Page 107

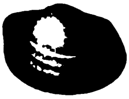
Fig. 17, 18 Lateral and anterior views of holotype. Natural size.
Schenectady beds. Schenectady, N. Y.

All originals are in the New York State Museum.

LOWER SILURIC FOSSILS.

N. Y. State Museum. Bull. 162

PLATE 6



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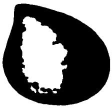

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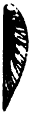

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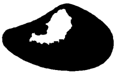

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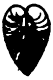

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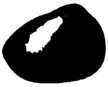

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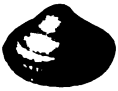

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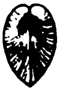

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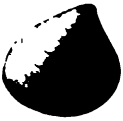

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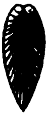

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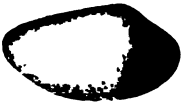

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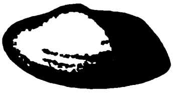

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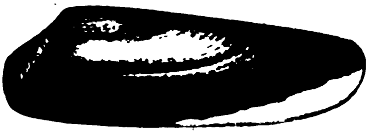

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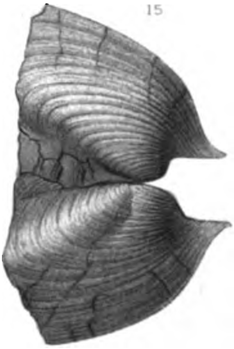

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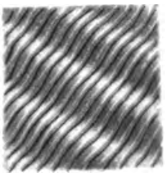

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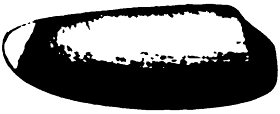

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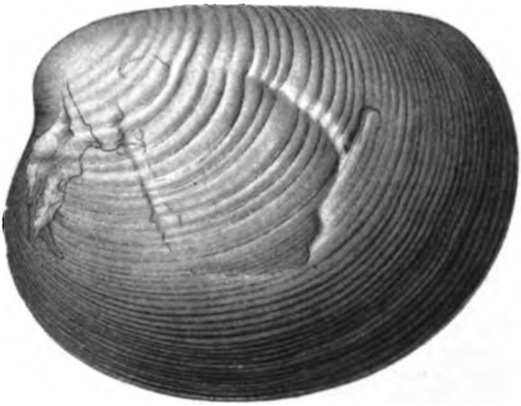

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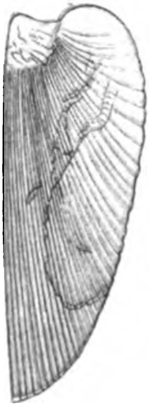

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Plate 7

Archinacella orbiculata (Hall)

Page 108

Fig. 1, 2 Very little distorted specimens. x 2. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.
Fig. 3, 4, 5, 6 Dorsal and lateral views of Hall's types. x 2.
Snake Hill shale. Near Waterford, N. Y.

Cyclonema montrealense Billings

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Fig. 7 Specimen. x 1.5. From squeeze.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Cyclonema cushingi nov.

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Fig. 8 Surface of holotype. Natural size. From squeeze.
Fig. 9 Cast of interior of same.
Fig. 10 Surface sculpture. x 5.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Pterotheca cf. **canaliculata** (Hall)

Fig. 11 Specimen, somewhat crushed. Natural size.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Hyolithes pinniformis nov.

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Fig. 12 Holotype, showing a septum near the apex. x 5.
Fig. 13 Paratype. x 5.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.
All originals are in the New York State Museum.

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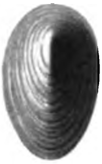

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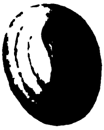

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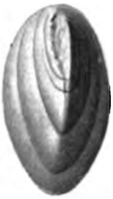

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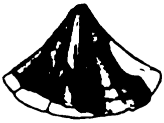

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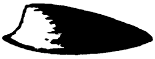

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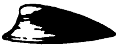

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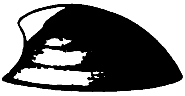

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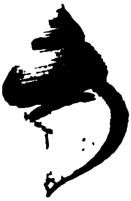

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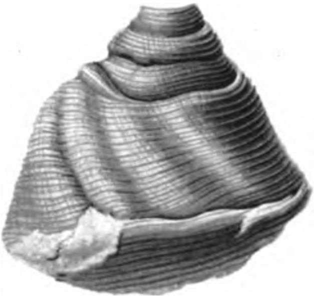

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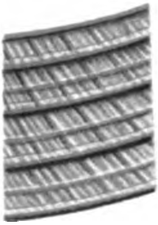

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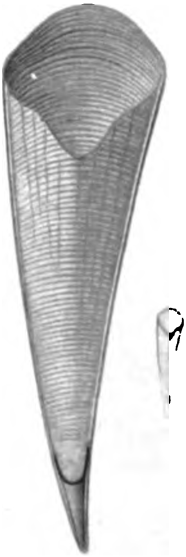

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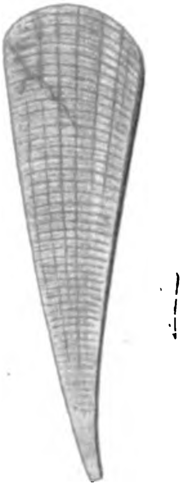

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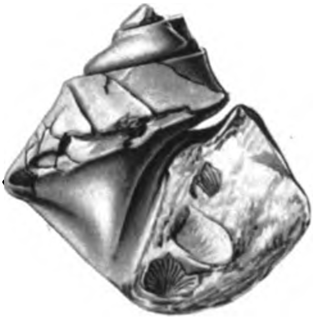

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Plate 8

Orthoceras arcuolineatum nov.

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Fig. 1 Holotype. Natural size.
Fig. 2 Section of same.
Canajoharie shales. Fort Edward, Saratoga county, N. Y.

Orthoceras hudsonicum nov.

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Fig. 3 Fragment showing the septa and surface sculpture. Natural size.
Fig. 4, 5 Two specimens showing the protoconch. x 5.
Fig. 6 Section of same, showing the first funnel at *a*. x 5.
Fig. 7 Straight specimen, from the Schenectady beds at the Dettbarn quarry near Schenectady and possibly different. Natural size.
Fig. 8, 9 Specimens that are slightly curved in the apical (neanic) region. Natural size.
Fig. 10 Section of neanic conch showing the closely arranged septa. Natural size.

The holotype (fig. 8) and the originals (paratypes) of figures 4, 5, 6, 9, 10 are from the Canajoharie beds at Alplaus; the original of figure 3 is from Watervliet, and that of figure 7 from the Dettbarn quarry at Schenectady.

Orthoceras cf. **amplicameratum** (Hall)

Fig. 11 Fragment, much compressed. Natural size.
Canajoharie shale. Near Glens Falls, N. Y.

Oncoceras (?) sp.

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Fig. 12 A completely flattened specimen.
Snake Hill beds. Signal Works near Albany, N. Y.

All originals are in the New York State Museum.

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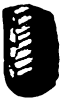

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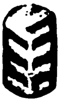

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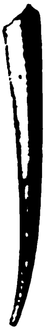

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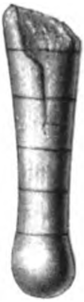

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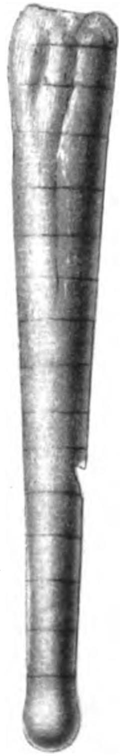

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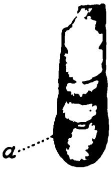

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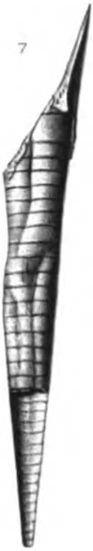

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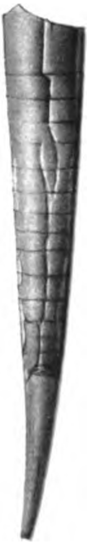

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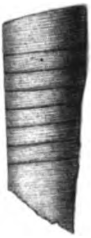

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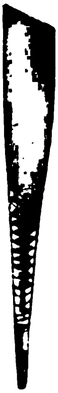

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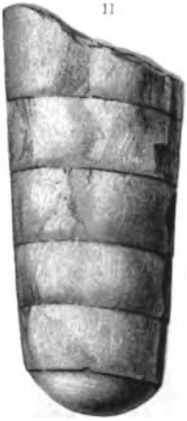

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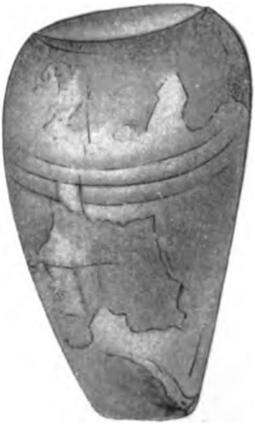

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Plate 9

Eoharpes ottawensis (Billings)

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Fig. 1 Specimen, somewhat laterally compressed. Natural size.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Proëtus undulostriatus (Hall)

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Fig. 2 Hall's type. x 3. From squeeze.
Fig. 3 Cranidium. x 3.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

Acidaspis crossota (Locke)

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Fig. 4 Free cheek. x 6.
Fig. 5 Cranidium. x 5.
Indian Ladder beds. Indian Ladder, Albany county, N. Y.

Calymmene senaria Conrad var.

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Fig. 6 Young, fairly complete individual, showing the medial tubercle on the occipital ring. Natural size.
Fig. 7 Protaspis stage. x 20.
Fig. 8 Nepionic stage. x 20.
Fig. 9 Early neanic stage, showing the appearance of the glabellar lobes in the glabellar furrows. x 20.
Fig. 10 Mature individual, much flattened. Natural size.
Canajoharie shale. Canajoharie and Sprakers (figure 10), Montgomery county, N. Y.

Ulrichia ? bivertex Ulrich

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Fig. 11 Right valve, showing normal expression of form. x 20.
Fig. 12 A left valve with slightly different aspect. x 20.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Primitiella unicornis Ulrich var.

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Fig. 13, 14 Two right valves showing the elongate form and the lateral node. x 20.
Canajoharie shale. Canajoharie, Montgomery county, N. Y.

Ceratopsis chambersi (Miller) var.

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Fig. 15 Left valve showing the average expression of the variety.
Indian Ladder beds. Indian Ladder, Albany, N. Y.

Eurychilina subradiata Ulrich

Fig. 16 Right valve. x 10.
Glens Falls limestone. Canajoharie, Montgomery county, N. Y.

Technophorus cancellatus Ruedemann

Page 122

Fig. 17 Right side of a somewhat imperfect carapace, retaining the surface sculpture. x 4.

Fig. 18 Cast of the interior of the right side retaining the undivided "beak." x 2.
Snake Hill beds. Snake hill, Saratoga county, N. Y.

All originals are in the New York State Museum.

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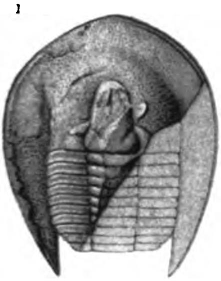

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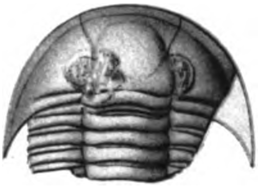

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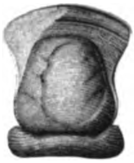

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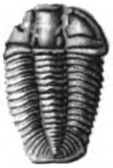

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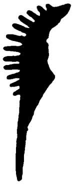

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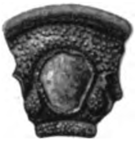

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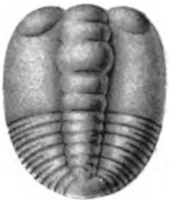

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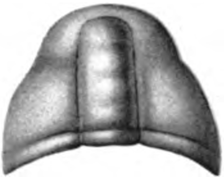

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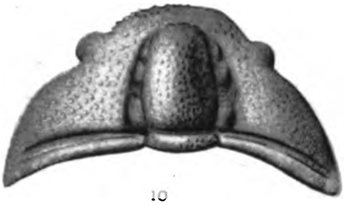

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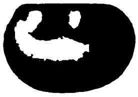

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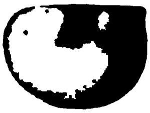

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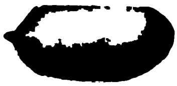

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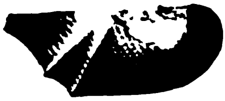

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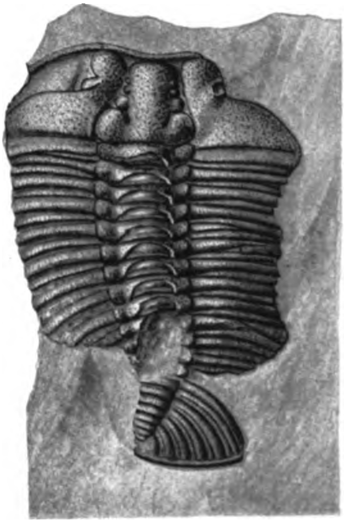

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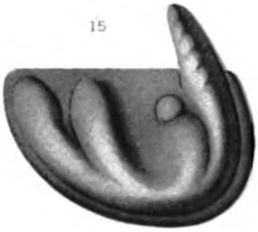

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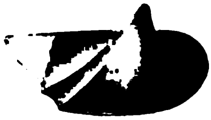

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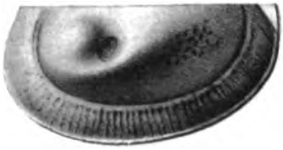

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Plate 10

Isotelus gigas DeKay

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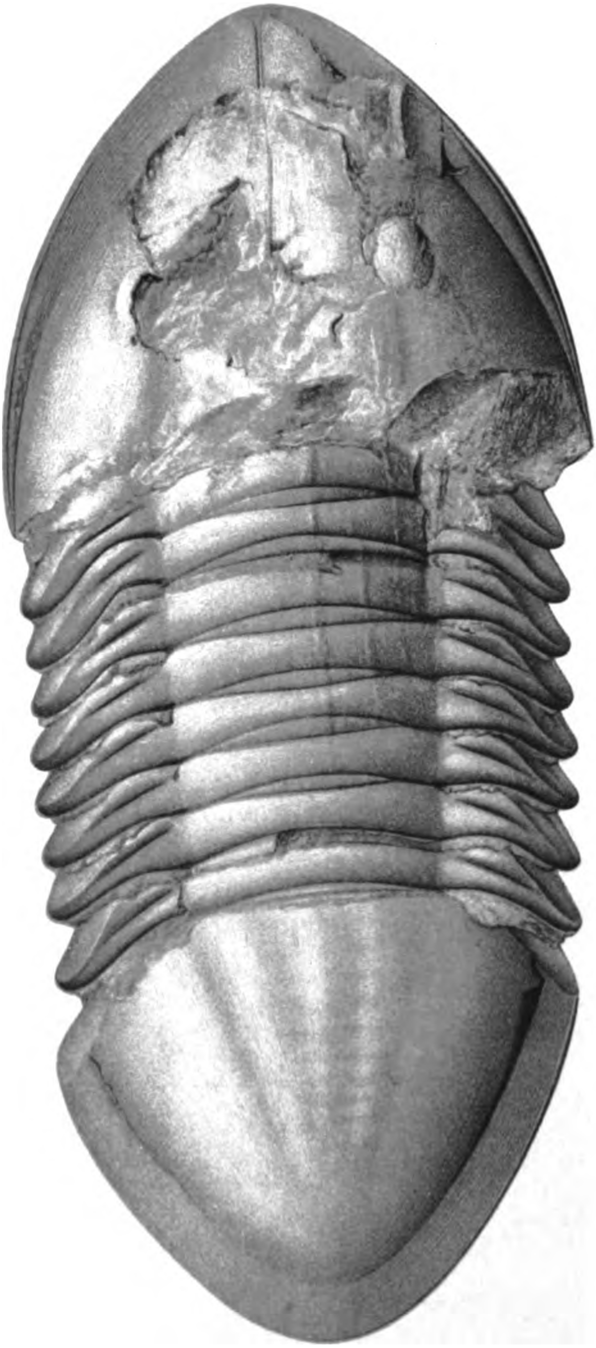
Fig. 1 Specimen somewhat laterally compressed, reproduced in natural size.

Schenectady beds. Rexford Flats, Saratoga county, N. Y.

Original in the New York State Museum.



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